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An Assessment of Teachers' Preparedness in Implementing Precision Agriculture in Competency-based Education in Secondary Schools in Kisii and Nyamira Counties, Kenya

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Abstract: *Precision Agriculture (PA) enhances efficiency and sustainable agricultural production. PA integration into secondary school agricultural education programs, particularly in Kenya, remains limited. This study assessed the preparedness of agricultural teachers to implement PA in Kisii and Nyamira Counties, Kenya. This study included 254 secondary schools and 353 teachers of agriculture were sampled using Cochran's finite population formula, proportionate random sampling, and purposive sampling. questionnaires and checklists were used to collect data. Content validity ensured that the instruments adequately measured teachers' preparedness, and Cronbach's alpha technique ensured that the instruments were reliable. Data was analyzed using SPSS version 27. Pearson's correlation and ANOVA examined the relationship between teacher preparedness and PA implementation, and differences in preparedness across levels of academic and professional training and PA implementation. The findings indicated a strong, positive, and statistically significant relationship between teacher preparedness and PA implementation ($r = 0.836$, $p < .001$), suggesting that teacher preparedness substantially influences PA implementation. ANOVA results showed statistically significant differences in preparedness across teachers' qualification levels ($F = 6.889$, $p < .001$), with higher training associated with preparedness. The overall regression model was statistically significant, $F(11, 340) = 112.30$, $p < .001$, explaining 78.4% of the variance in PA implementation, $R^2 = .784$. In conclusion, teachers' preparedness is critical to PA implementation, with higher levels of preparedness indicating readiness. This study, therefore, recommends that teacher training programs be designed to engage educators in hands-on, experiential learning that promotes knowledge construction.*

Keywords: *Precision Agriculture, Teacher Preparedness, Competency-Based Education, Agriculture Education, Technology Integration in Education, Kisii and Nyamira Counties, Kenya*

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1. Introduction

Precision Agriculture (PA) is the application of the correct quantity of inputs of agriculture in the appropriate place in the field for maximum yields, and advanced long-term sustainability (United Nations Development Program UNDP, 2021). In the context of secondary school, it refers to the extent to which teachers of agriculture possess the knowledge, skills, and capacity to integrate data-driven and technology-based farming concepts into teaching and learning processes in secondary school agricultural education**.** PA could undeniably be the mainstay for revolutionizing food production, solving food insecurity, by effectively managing agricultural resources through the use of information technology, which is in line with Sustainable Development Goal 2(zero hunger), and unlocking new avenues of employment. PA addresses issues of global food security and environmental pollution by effectively managing agricultural resources through the use of information technology (Erickson *et al.,* 2021). According to a 2017 survey by Balafoutis *et al.,* PA is a data-driven farming that adapts techniques to the unique requirements of various crops and fields. To ensure the efficient and sustainable use of resources, this agricultural approach utilizes cutting-edge technologies (Association of Equipment Manufacturers, 2023). While scholars debate its exact definition, many agree that PA relies on precise field data to make decisions on the best practices of agronomy (Shannon *et al.,* 2018).

PA serves a major role in the employment of many countries' economically active population, in Kenya, and in Kisii and Nyamira Counties. Succinctly, Agriculture employs over 60% of the nation's economically active population, which is rapidly growing (KIPPRA, 2024). Traditionally, farmers used conventional methods like spreading inputs evenly over whole fields, leading to wastage of farm inputs. Proper implementation of PA will optimize resources for higher productivity and profitability by dividing fields into management zones based on information like crop production and soil variability (Shiferaw *et al.,* 2009). PA optimizes efficiency and sustainability by giving crops precisely what they require, when they need it, and where they need it (Nelson, 2023). Enhancing the agricultural profession, encouraging an eco-friendly approach, and optimizing resource use are some of its objectives, contributing to the attainment of SDG 12 (Responsible consumption and production) (Kutigi *et al.,* 2019).

The agriculture sector is the highest employer in Kisii and Nyamira Counties. A survey conducted by the Kenya Institute for Policy Research and Analysis (KIPPRA) in 2024 indicated that 60% of Kisii and Nyamira County dwellers depend on Agriculture directly for employment. Moreover, the average population growth in the Counties is 1.6%, and the overall poverty index of 37.2% (KIPPRA 2024), despite this state and many benefits associated with PA technology, its adoption rate is still very low, not only in secondary schools but also on the farms, despite the fact it has been in existence since the 1990s (Bagheri & Naier, 2022). Whereas slow uptake of PA in America is associated with a lack of PA knowledge and experience (Chad, 2022), in Kenya, particularly in Kisii and Nyamira Counties, the state of adoption and implementation in terms of teacher preparation remains unresolved. Even though acceptance and implementation of innovations depend on knowledge and education Rogers, 2003), in Kisii and Nyamira Counties, the Knowledge and education on PA practices of teachers of agriculture equally remain unclear, underscoring the need to assess teachers' Preparedness in PA implementation in Kisii and Nyamira counties, Kenya.

Agriculture globally faces the dual challenge of increasing food production sustainably while minimizing environmental degradation. Precision Agriculture (PA), which utilizes advanced technologies to optimize resource use, enhance productivity, and reduce pollution from agricultural inputs, has emerged as a transformative approach to addressing these challenges (Walter et al., 2017; Sharma & Srushtideep, 2022). In Kenya, the Competency-Based Education (CBE) curriculum seeks to equip secondary school learners with practical, real-world skills relevant to modern agricultural practices. Although PA-related concepts such as irrigation management and efficient resource utilization are incorporated in the agricultural curriculum, a gap remains between curriculum intentions and their effective implementation in schools. This gap is particularly evident in Kisii and Nyamira Counties, where agriculture employs about 60% of the population amidst rapid population growth and shrinking land sizes (KIPPRA, 2024; Kisii County CIDP 2023–2027), necessitating the adoption of high-efficiency farming approaches. However, the extent to which PA concepts are effectively integrated and taught as practical competencies in secondary school agricultural education remains unclear. Furthermore, the preparedness of teachers, the availability of technological infrastructure, and pedagogical challenges influencing the integration of PA within the CBE framework have not been adequately assessed. Consequently, many students who engage in farming after completing secondary education may graduate without the necessary competencies to apply modern, technology-driven agricultural practices. This gap not only limits the modernization of agriculture in the region but also undermines the potential of secondary schools as centers for agricultural knowledge transfer and community extension. Therefore, this study seeks to assess the preparedness of secondary school agriculture teachers in the implementation of Precision Agriculture within secondary school agricultural education in Kisii and Nyamira Counties to generate empirical evidence that can inform policy, strengthen teacher preparedness, and enhance the integration of PA competencies within the CBE framework

2. Literature Review

Teachers' role in education cannot be overstated; Kyule (2017) notes that when the qualified teachers are available, the implementation of curriculum becomes successful, and Aslam *et al.,* (2016) further noted the key determinants of curriculum success or failure are teachers, this is because they facilitate learning and are responsible for creating conditions that increase the effectiveness and efficiency of the learning process (Anisah & Widyantoro, 2019). They also oversee the organization, application, and innovation in materials used for educational purposes. Disciplines like agriculture need teachers who can manage resources strategically, as they are resource-intensive; therefore, the role of a teacher becomes even more important. The need for qualified teachers to impart desirable attitudes, knowledge, and skills in learners is one of the major concerns of policymakers in educational setups around the world (Ye, Zhu, & Lo, 2019). According to Chemutai (2020), a teacher who is competent manifests mastery of content, exhibits a wide range of pedagogical skills, and has strong interpersonal and ability to communication skills, all of which are important for the implementation of PA. However, in Kisii and Nyamira Counties, the level of teacher knowledge and skills in PA remains unclear, underscoring the need for this study.

In Countries that have developed, like Luxembourg, the qualifications of a teacher are a top priority. According to Karani *et al.* (2021), prior to certification and securing employment, teachers must pass examinations of the state examinations. This focus was advanced by UNESCO (2006) in an education development conference in Addis Ababa, which emphasized the need to increase facilities for training future teachers with the skills and knowledge necessary to utilize and adapt instructional materials effectively. However, there is an inconsistency in executing these suggestions across many African nations, for instance, in Tanzania, the introduction of PA has been impeded by a lack of trained teachers Chonjo, 2018). A similar situation may exist in Kenya, particularly in Kisii and Nyamira Counties, where the level of teacher preparedness for PA integration remains uncertain, thereby providing a basis for the present study.

3. Methodology

3.1 Location of the Study

The study was carried out in Kisii and Nyamira Counties in the selected Schools. Agriculture is the main economic activity in the two Counties, with an estimated contribution of 45% in Kisii County and 53% in Nyamira County, gross domestic product (Gross County Report (GCP) 2021). The population in the two Counties is dense, with 957 persons per square kilometer as opposed to the national figure of 82 (KEBS, 2019). Kisii and Nyamira Counties are therefore justified in this study, both counties heavily rely on agriculture as the main source of livelihood, yet the population in the two counties is growing rapidly, resulting in reduced land size, which makes it ideal for integrating PA into the farming system. Educational infrastructure in these counties has expanded significantly, with many Schools offering agriculture as a subject, making them appropriate for assessing the implementation of PA, technology-based agricultural pedagogy.

3.2 Research Philosophy

The pragmatist paradigm guided this study. Pragmatism as a paradigm asserts that for knowledge to be acquired, the man must interact with his environment. Pragmatism emphasizes that the best way to understand the world and address its problems is by applying both objective and subjective approaches. Pragmatism yields mixed methods research (MMR). Also, pragmatists take into account both the objective quantitative perspective and the subjective perceptions of stakeholders. The two approaches situate the research problem within its proper context (Foster, 2024).

3.3 Research Design

This study employed a concurrent transformative Mixed Methods Research (MMR) design within an overall cross-sectional survey approach. The core of the methodology was the concurrent transformative mixed methods design. In this design, both quantitative and qualitative data are collected simultaneously, analyzed separately, and then merged or triangulated during the interpretation phase (Schoonenboom & Johnson, 2017).

3.4 Sampling and Samples

Stratified proportionate random sampling was used to select 254 secondary schools from the two counties. Purposive sampling was used to select 353 teachers of agriculture from the two Counties. The sample size was determined by Cochran's formula of $n = n_0 / (1 + (n_0 - 1) / N)$

n = Adjusted sample size for a finite population

n_0 = Initial Cochran sample size

N = Total population size

n = 574 / (1 + (574 − 1) / 915) = 353

3.5 Data Collection Tools

To achieve the objective of this study, both quantitative and qualitative tools were used. The combination enhances triangulation, ensuring that the data collected is comprehensive, reliable, and valid. The tools include questionnaires, and observation schedules.

3.6 Validity and Reliability

The researcher enhanced the validity of the instruments through content technique by taking time to comply with the formalities and procedures adopted in developing research instruments, then gave them to the supervisors and peers in the area of study, who reviewed them and made comments after critically assessing the content and determining its relevance and appropriateness. Cronbach's alpha was used to test for the reliability of instruments.

3.7 Data Collection Procedure

An introduction letter was obtained from the university directorate of postgraduate studies. The letter was used to apply for a research permit from NACOSTI. Upon receiving the letter, Kisii and Nyamira County Commissioners were contacted who in turn cleared the researcher to the Directors of education and TSC County directors who introduced the researcher to the respective Sub-Counties. The Sub-Counties, in turn, linked the researcher to the respective schools within the sampled Sub-Counties

3.8 Data Analysis

This objective involves the analysis of teachers' preparedness and its influence on the implementation of PA. Qualitative analysis was used to assess teachers' attitudes towards the implementation of PA. Univariate statistics included computation of means, standard deviation, and frequencies. Bivariate analysis involved several tests. ANOVA was used to assess the difference in PA implementation as explained by teachers' qualifications/levels of training (measured as PhD, Master's, undergraduate, and diploma). Pearson's correlation was used to assess the strength and direction between teachers' experience (years of service) and PA implementation composite scores. Additionally, Pearson's r was used to assess the strength and direction between teachers' ICT skills, as measured using a Likert scale, and PA implementation scores. Moreover, a correlation between teachers' age (continuous variable) and PA implementation was established. Equally, the study established the differences in PA implementation as explained by teachers' age using an independent t-test.
Multivariate analysis involved the use of Multiple linear regression (MLR) to assess the effect sizes of the predictors on the continuous outcome (PA implementation composite scores). The MLR involved two models, model 1 and model 2. Model 1 will include the effect of predictors on the outcome without the intervening variables. The second model will include intervening variables.
The model formula is as shown below;

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(i)$$

Where y is the PA implementation composite scores
β_0 Is the constant value (value of y with no predictors).
β_1 -β_5 These are the coefficients of all the predictors.
X_1 -X_5 These are the main predictors in the first objective.
ϵ is the error term.
The model assumptions will be checked using normality (Karnel Density Estimate) and multicollinearity (Variance inflation factor (VIF) < 5), tests to ensure the fitness of the model.

3.9 Ethical Considerations

All respondents were clearly informed about the objectives, purpose, and expected outcomes of the study before participating. Participation was voluntary, and no respondent was coerced or manipulated into taking part. Respondents had the right to withdraw from the study at any stage without penalty. Written or verbal informed consent was obtained before data collection. Respondents were advised not to write their names or any personal identifiers on questionnaires to ensure anonymity. For interviews, codes or pseudonyms were used in place of real names when recording or reporting data.

4. Results and Discussion

Preparedness of teachers in PA implementation was investigated by the use of selected demographic and professional characteristics, namely: gender, age, level of education, teaching experience, and technical familiarity with selected PA-related competencies, including the use of laptops in instruction and interpretation of basic soil reports.

4.1 Gender of teachers of agriculture in Kisii and Nyamira Counties, Kenya

To determine the distribution of teachers of agriculture by gender and its implications on PA, respondents were asked to indicate their gender. The findings revealed that 204 (57.5%) of the sampled teachers were male, while 149 (42.5%) were female (Table 1). This indicates that teaching of agriculture in secondary schools within the two Counties was dominated by men. However, the distribution of gender alone does not imply variation in the engagement of PA implementation, thus necessitating bivariate analysis. To justify whether gender significantly influenced PA implementation, an independent t-test was conducted to compare the implementation scores of PA between male and female teachers. Results revealed that the difference in PA implementation between male and female teachers was not statistically significant ($t(351) = 1.692$, $p=0.092>0.05$) Table 2. Despite Males having a slightly higher mean in PA implementation score (M=3.4, SD=0.414), contrary to their female counterparts (M=2.95, SD= 0.032) as indicated in Table 3, the difference observed is not statistically significant. This connotes that gender does not influence the level of PA implementation meaningfully among teachers of agriculture in Kisii and Nyamira Counties. This finding aligns with the assertion by Anisah and Widyantoro (2019) that the effectiveness of curriculum implementation depends more on teacher competence and facilitation skills rather than demographic characteristics such as gender. Similarly, Ye, Zhu, and Lo (2019) emphasize that professional competence, rather than personal attributes, determines the effectiveness of teaching and curriculum implementation.

Table 1: Gender of teachers of agriculture in Kisii and Nyamira Counties

Gender	Frequency (F)	percent (%)	Total percent (%)
Female	149	42.5	42.5
Male	204	57.5	57.5

N=353

Table 2: An independent t-test for gender against PA implementation

		F	**Sig**	**T**	**Df**	**Sig (2-tailed)**	**Mean difference**
PA	Equal variances	3.852	0.050	1.692	351	0.092	0.09538
	Equal variances assumed			1.722	337.203	0.086	0.09538

Table 3: Means of respective gender against PA implementation

Group Statistics					
	gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
PA	male	204	**3.04**	.414	.029
	female	149	**2.95**	.389	.032

4.2 Age of teachers of agriculture in Kisii and Nyamira Counties, Kenya

Teachers were also asked to indicate their age. As indicated in Table 4, the majority of the teachers (204;57.8%) were aged between 35 and 50 years. 19-34years represented the second largest age group (120;33.9%), while 51-60 years was the smallest age group (20; 8.3%). To determine the relationship between age and PA implementation, Pearson's product-moment correlation was conducted. Results revealed a strong, positive, statistically significant relationship between age and PA implementation (r=0.675, *p<0.05)* as indicated in Table 5, which means that older teachers manifested higher PA implementation levels compared to younger teachers. This finding is in line with Rogers' theory of diffusion of innovations, which stipulates that adoption of innovations to a great extent is influenced by an increase in experience (age). The implementation of PA in secondary schools also increases with an increase in the age of teachers of agriculture This finding supports the Diffusion of Innovations theory by Rogers (2003), which posits that adoption and implementation of innovations often increase with experience and exposure over time. Older teachers are likely to have accumulated more pedagogical experience and professional exposure, which enhances their ability to integrate emerging technologies such as Precision Agriculture into classroom instruction. Furthermore, Chemutai (2020) notes that experienced teachers tend to demonstrate stronger mastery of instructional content and pedagogical skills, factors that are essential in implementing technology-driven agricultural concepts.

Table 4: Age of teachers of agriculture in Kisii and Nyamira Counties, Kenya

Age range	Frequency (F)	Percent (%)
19-34 yrs	110	33.9
35-50 yrs*	204	57.8
51-60 yrs	29	8.3

N =353

Table 5: Pearson's correlation between age and PA implementation in Kisii and Nyamira Counties, Kenya

		PA	Age
PA	Pearson Correlation	1	0.675**
	Sig. (2-tailed)		.000
	N	353	353
Age	Pearson Correlation	0.675**	1
	Sig. (2-tailed)	.000	
	N	353	353

**. Correlation is significant at the 0.01 level (2-tailed).

4.3 Level of education of teachers of agriculture in Kisii and Nyamira Counties, Kenya

This study also examined the academic qualifications of teachers of agriculture across the two Counties as a prerequisite towards PA implementation. From the findings in Table 6, the majority of the teachers had a Bachelor of Education (BED) (149; 42.2%), followed by a Bachelor of Science in agriculture education and extension (BSC. Aged) (138; 39.1%). Those with postgraduate qualifications constituted a very small proportion. One-way analysis of variance was conducted to determine whether PA implementation differed significantly across teachers' academic qualifications. The findings from

ANOVA revealed a statistically significant difference in PA implementation among teachers with different academic qualifications ($F(5, 347) = 6.294$, p val=0.000) as captured in Table 7. This means that teachers' educational level significantly influences their level of participation in PA implementation, where teachers with higher academic qualifications were more involved in PA implementation. This finding is consistent with the views of Karani, Wanjala, and Njoroge (2021), who argue that higher levels of teacher education enhance professional competence, technological awareness, and the ability to implement innovative instructional approaches. Similarly, UNESCO (2006) emphasized the importance of strengthening teacher training programs to equip educators with the necessary knowledge and skills to effectively utilize modern instructional technologies.

Table 6: Education level of agriculture teachers in Kisii and Nyamira Counties, Kenya.

Education level	**Frequency (F)**	**Percent (%)**
Diploma	39	11
BED	149	42.2
BSC(AGED)	138	39.1
Postgraduate	3	0.8
Masters	19	5.4
PhD	5	1.4

N=353

Table 7: ANOVA on the level of education of agriculture teachers and PA implementation

	Sum of Squares	**Df**	**Mean Square**	**F**	**Sig.**
Between Groups	4.824	5	.965	6.294	.000**
Within Groups	53.192	347	.153		
Total	58.016	352			

4.4 Years of experience of agriculture teachers in Kisii and Nyamira Counties, Kenya

Another teacher preparedness dimension in PA implementation under this study was teaching experience. From the findings, the majority of teachers had an experience of 6-10 years (138;39.1%). Teachers with 0-5 years accounted for 86 (24.4%), while those with 20 years formed 10.5% of the sample. (Table 8). Pearson's product correlation showed a weak but statistically significant relationship between teaching experience and PA implementation, as shown in Table 4.9 ($r=0.315$, $p=0.000<0.05$) (Table 9). This indicates that though teaching experience contributes to PA implementation, its influence is somewhat modest. The finding supports Kyule (2017), who observed that while teacher experience contributes to effective curriculum implementation, other factors such as access to training, institutional support, and technological infrastructure may play a more dominant role. In the context of PA, which involves digital technologies and data-driven farming practices, experience alone may not be sufficient unless it is complemented by specialized training and exposure to emerging agricultural technologies

.**Table 8: Teachers of agriculture teaching experience in Kisii and Nyamira Counties**

Years of experience	Frequency (F)	Percent (%)
0-5	86	24.4
6-10	138	39.1
11-15	50	14.2
16-20	41	11.6
20 and above	37	10.5

N=353

Table 9: Pearson's correlation between years of experience and PA implementation in Kisii and Nyamira Counties, Kenya.

		years taught	PA
years taught	Pearson Correlation	1	.315**
	Sig. (2-tailed)		.000
	N	353	353
PA	Pearson Correlation	.315**	1
	Sig. (2-tailed)	.000	
	N	353	353

**. Correlation is significant at the 0.01 level (2-tailed).

4.5 Teachers of agriculture's familiarity with using a laptop to teach PA

As part of PA implementation, teachers' ability to integrate laptops into teaching PA was necessary. The teacher's ability was ranked between a scale of 1-5 familiarity scale, where 1=Not aware, 2= heard of it, 3=somewhat familiar, 4=familiar, and 5=very familiar. From the univariate analysis, the majority of the teachers were familiar with using a laptop to teach PA concepts; however, very few were very familiar with using the laptop to teach PA concepts (Table 10). Mean of the respective familiarity index was then computed against PA implementation scores; the results indicated an average of 3.01 (Table 11), which implied most teachers were somewhat familiar. According to Erickson, Widmar, and Kennedy (2021), successful implementation of digital agriculture concepts requires teachers to possess adequate technological competence in order to effectively demonstrate data-driven agricultural practices. Similarly, Balafoutis et al. (2017) emphasize that precision agriculture relies heavily on digital technologies, making ICT proficiency an essential component of effective PA education.

Table 10: Familiarity Level Index of Teachers of Agriculture to use a laptop to teach PA concepts

Level of familiarity	Frequency	Percent (%)
Not aware	48	13.6
Heard of it	81	22.9
Somewhat familiar	35	9.9
Familiar	172	48.7
Very familiar	17	4.8

Table 11: Familiarity mean level index of teachers of agriculture to use a laptop to teach PA concepts

Laptop familiarity PA	Mean	N	Std. Deviation
Not aware	2.96	48	.459
Heard of it	3.01	81	.432
Somewhat familiar	2.96	35	.416
Familiar	2.97	172	.347
Very familiar	3.50	17	.367
Total	**3.01**	**353**	**.406**

4.6 Teachers of agriculture's familiarity with interpreting basic soil reports in the implementation of PA

For effective and efficient implementation of PA in secondary schools in Kisii and Nyamira Counties, teachers' ability to interpret soil reports was investigated. From the findings, the majority of the teachers could only interpret soil with assistance (43.1%), 28.9% could not interpret the report, while 28 % could interpret independently, as captured in Table 12. The means of the respective familiarity index of soil interpretation were then computed against PA implementation scores; the results indicated an average of 3.00 (Table 13), which implied that most teachers could interpret soil reports. This finding is consistent with Bagheri and Naier (2022), who identified limited technical expertise as a major barrier to the adoption and implementation of Precision Agriculture technologies in many developing regions. Similarly, Chonjo (2018) observed that inadequate training of agricultural educators can hinder the effective integration of modern agricultural technologies in educational systems.

Table 12: Teachers of agriculture's familiarity with interpreting basic soil reports in the implementation of PA

Level of familiarity	Frequency	Percent (%)
Cannot	102	28.9
With assistance	152	43.1
Independently	99	28

N=353

Table 13: Teachers of agriculture familiarity index mean in interpreting basic soil report in the implementation of PA

Ability to interpret soil report PA	Mean	N	Std. Deviation
Cannot	2.67	102	.276
Heard of it	2.98	152	.306
Somewhat familiar	3.39	99	.312
Total	**3.00**	**353**	**.406**

4.7 Teachers of agriculture's familiarity with soil mapping in Kisii and Nyamira Counties

In preparation for PA implementation and its feasibility, it was necessary to determine teachers' knowledge and ability to carry out soil mapping. The results in revealed that 141(39.9%) were familiar, 96(27.2%) had just heard about it, 55(15.6%) were somewhat familiar, 46(were not aware) and 15(4.2%) were very familiar. From the findings, the majority of the teachers were familiar with soil mapping (39.9%); however, very few were very familiar, as indicated in Figure 1. This points to some gaps in terms of knowledge about soil mapping. This finding is consistent with Bagheri and Naier (2022), who identified limited technical expertise as a major barrier to the adoption and implementation of Precision Agriculture technologies in many developing regions. Similarly, Chonjo (2018) observed that inadequate training of agricultural educators can hinder the effective integration of modern agricultural technologies in educational systems.

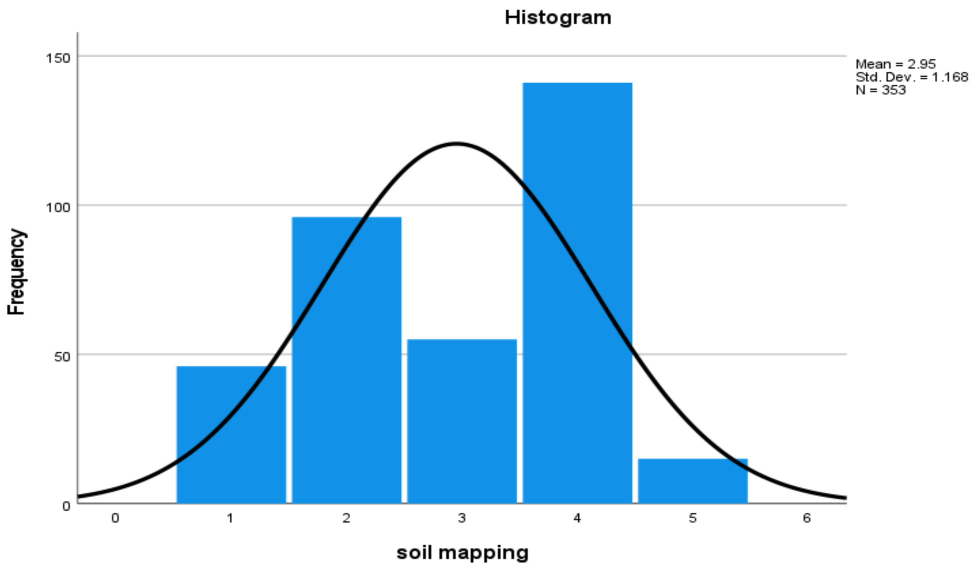

Figure 1: **Teacher's ability to conduct soil mapping**

4.8 Relationship Between Teacher Preparedness and Implementation of Precision Agriculture (PA)

To determine whether there is a relationship between the preparedness of teachers and the implementation of PA education programs in secondary school, a Pearson Product-Moment Correlation analysis was carried out. The analysis was based on responses from 353 teachers. The findings indicated a strong, positive, and statistically significant relationship between teacher preparedness and PA implementation ($r = 0.836$, $p < .001$) as captured in Table 14. This correlation coefficient implies a high degree of association; higher levels of teacher preparedness are strongly linked to more effective implementation of PA concepts in agricultural education. The magnitude of the correlation ($r = 0.836$) implies that teacher preparedness plays a substantial role in influencing PA implementation. Specifically, teachers who demonstrated higher levels of preparedness, as evidenced by adequate pedagogical skills, content knowledge, technological competence, and exposure to PA-related training, were more likely to effectively integrate Precision Agriculture practices into their teaching. Conversely, lower levels of preparedness were associated with weaker implementation outcomes.

The statistical significance of the relationship at the 0.01 level confirms that the observed association is unlikely to have occurred by chance, thereby providing robust empirical evidence in support of the study's objective. These findings underscore the centrality of teacher preparedness as a critical determinant in the successful implementation of Precision Agriculture within secondary school agricultural education programs.

Overall, the results affirm that enhancing teacher preparedness is likely to yield substantial improvements in the adoption and integration of Precision Agriculture, reinforcing the need for targeted professional development, capacity building, and institutional support mechanisms aimed at strengthening teachers' readiness to implement PA innovations effectively. These results support the argument by Aslam, Rawal, and Aslam (2016) that teachers are central actors in curriculum implementation, and their competencies directly influence the success or failure of educational innovations. Similarly, Kyule (2017) notes that the presence of well-trained and competent teachers significantly enhances the effective delivery of curriculum content, particularly in subjects that require practical and technological competencies such as agriculture.

Table 14: Relationship Between Teacher Preparedness and Implementation of Precision Agriculture (PA)

		Implementation	Teacher prep
Implementation	Pearson Correlation	1	.836**
	Sig. (2-tailed)		.000**
	N	353	353
Teacher prep	Pearson Correlation	.836**	1
	Sig. (2-tailed)	.000**	
	N	353	353

**. Correlation is significant at the 0.01 level (2-tailed).

4.9 Multiple linear regression of teacher preparedness and PA implementation in secondary schools

To determine whether teacher preparedness was significant in PA implementation, a multiple linear regression analysis was conducted to examine whether age, gender, level of education (BSc, BEd, Postgraduate, Masters, and PhD compared to Diploma), years taught, laptop familiarity in PA, soil mapping skills, and ability to interpret soil reports predicted PA implementation among secondary school agriculture teachers.

The overall regression model was statistically significant, F (11, 340) = 112.30, $p < .001$, explaining 78.4% of the variance in PA implementation, $R^2 = .784$. This indicates that the predictors collectively contributed significantly to explaining variation in PA implementation.

Regarding individual predictors, age was a strong and significant positive predictor of PA implementation ($\beta = .702$, $t = 14.55$, $p < .001$). This implies that older teachers demonstrated a higher likelihood of implementing PA concepts in their teaching. This finding is consistent with Rogers (2003), who argues that experience and prolonged exposure to professional practice can enhance an individual's ability to adopt and apply innovations. The ability to interpret soil reports also significantly predicted PA implementation ($\beta = .139$, $t = 3.69$, $p < .001$) This finding highlights the importance of technical agricultural competencies in facilitating the integration of Precision Agriculture concepts in education. Precision Agriculture relies heavily on field-specific data such as soil nutrient levels, crop performance indicators, and environmental conditions (Balafoutis et al., 2017). Therefore, teachers who possess the ability to interpret soil data are more likely to incorporate data-driven decision-making concepts into agricultural education. Years taught were a significant positive predictor ($\beta = .071$, $t = 2.61$, $p = .009$). Additionally, teachers with a PhD differed significantly from Diploma holders ($\beta = .072$, $t = 2.61$, $p = .010$), indicating higher levels of PA implementation among PhD holders. Laptop familiarity in PA was also statistically significant ($\beta = 060$, $t = 2.06$, $p = .040$), this finding underscores the critical role of digital literacy in the adoption of Precision Agriculture education. Erickson, Widmar, and Kennedy (2021) emphasize that digital technologies form the backbone of modern precision agriculture systems, and therefore teachers must possess sufficient ICT skills to effectively integrate these technologies into agricultural education programs.

Gender ($p = .858$), BSc versus Diploma ($p = .572$), BEd versus Diploma ($p = .101$), Postgraduate versus Diploma ($p = .483$), Masters versus Diploma ($p = .572$), and soil mapping ($p = .100$) were not statistically significant predictors of PA implementation as captured in Table 15.

Table 15: Multiple linear regression of teacher preparedness and PA implementation in secondary schools

Model	Sum of squares	Df	Mean square	F	Sig
Regression	75.643	11	6.877	112.297	.001^{b}
Residual	20.820	340	.0.61		
Total	96.463	351			

Dependent Variable: PA implementation R Square =0.784

predictors: (constant), interpret soil basic report, PhD vs diploma, male vs female, postgraduate vs diploma, bed vs diploma, master's vs diploma, years taught, laptop familiarity pa, soil mapping, BSc vs diploma, age

4.10 Observation checklist results

The results from observation checklist indicated a relatively low level of integration of Precision Agriculture (PA) practices in schools. Only 115 schools (22.7%) reported that teachers use digital agriculture tools in instruction, suggesting that the majority of schools have not yet adopted technologies such as mobile applications, sensors, or GPS based tools that support modern agricultural practices. Additionally, 154 schools (30.4%) showed evidence of data-based farm instruction, indicating that although some teachers incorporate farm records and data analysis in teaching, most schools still rely on traditional methods rather than data-driven agricultural decision-making. More notably, only 55 teachers (10.8%) had verified records of training in Precision Agriculture, highlighting a significant gap in teacher preparedness to implement PA concepts in agricultural education. This limited training may hinder teachers' ability to effectively integrate digital and data-based agricultural practices into teaching and learning. Overall, the findings suggest that the adoption of Precision Agriculture in school agricultural programs remains minimal and underscore the need for increased teacher training, improved access to digital tools, and stronger institutional support to enhance the integration of modern agricultural technologies in education.

5. Conclusion and Recommendations

5.1 Conclusion

Teacher preparedness constitutes the central and most powerful driver of PA implementation. Overall, the results affirm that enhancing teacher preparedness is likely to yield substantial improvements in the adoption and integration of Precision Agriculture, reinforcing the need for targeted professional development, capacity building, and institutional support mechanisms aimed at strengthening teachers' readiness to implement PA innovations effectively

5.2 Recommendations

The Ministry of Education and Kenya Institute of Curriculum Development (KICD) should incorporate explicit, measurable Precision Agriculture performance competencies (at least 4–6 observable indicators per grade level) into the agriculture curriculum during the 2028–2032 CBE review cycle for agriculture teachers.

The Teachers Service Commission (TSC) and Teacher Training Institutions should introduce compulsory Precision Agriculture and digital agriculture course units (minimum 45 contact hours) in all pre-service Bachelor of Education (Agriculture) and Diploma in Agricultural Education programs by the 2027/2028 academic year.

References

Anisah, N., & Widyantoro, A. (2019). Teacher roles in facilitating effective learning processes. *Journal of Education and Learning, 13*(2), 145–152.

Aslam, H. D., Rawal, H., & Aslam, S. (2016). Teacher competencies and their influence on curriculum implementation. *International Journal of Educational Development, 45*, 1–7.

Association of Equipment Manufacturers. (2023). *Precision agriculture technology adoption report*. Association of Equipment Manufacturers.

Bagheri, A., & Naier, A. (2022). Adoption of precision agriculture technologies and barriers to implementation. *Computers and Electronics in Agriculture, 192*, 106598.

Balafoutis, A., Beck, B., Fountas, S., Vangeyte, J., Van der Wal, T., Soto-Embodas, I., Gómez-Barbero, M., Barnes, A., & Eory, V. (2017). Precision agriculture technologies are positively contributing to greenhouse gas emissions mitigation, farm productivity, and economics. *Sustainability, 9*(8), 1339. https://doi.org/10.3390/su9081339

Chad, M. (2022). Barriers to the adoption of precision agriculture technologies in the United States. *Journal of Agricultural Technology Management, 11*(3), 34–45.

Chemutai, R. (2020). Teacher competence and its influence on effective teaching and learning in secondary schools. *International Journal of Education and Research, 8*(5), 123–134.

Chonjo, P. (2018). Adoption of precision agriculture technologies in Tanzania: Challenges and opportunities. *African Journal of Agricultural Research, 13*(24), 1201–1210.

Erickson, B., Widmar, D., & Kennedy, T. (2021). Digital agriculture and precision farming: A review of emerging technologies and adoption trends. *Agricultural Systems, 190*, 103107.

Foster, J. (2024). *Research paradigms and methodologies in social science research*. Routledge.

Gross County Product (GCP). (2021). County gross product report: Kisii and Nyamira counties. Kenya National Bureau of Statistics.

Karani, F., Wanjala, G., & Njoroge, P. (2021). Teacher qualifications and professional development in education systems. *International Journal of Educational Policy Research, 9*(2), 56–67.

Kenya Bureau of Statistics (KEBS). (2019). *Kenya population and housing census analytical report*. Kenya National Bureau of Statistics.

Kenya Institute for Public Policy Research and Analysis (KIPPRA). (2024). *Kenya Economic Report 2024*. KIPPRA.

Kutigi, A., Abdulai, A., & Fuseini, A. (2019). Sustainable agricultural development and resource efficiency in sub-Saharan Africa. *Sustainability, 11*(15), 4132.

Kyule, P. (2017). Teacher availability and curriculum implementation in secondary schools in Kenya. *International Journal of Educational Administration and Policy Studies, 9*(6), 64–72.

Nelson, R. (2023). Precision agriculture and sustainable farming systems. *Journal of Sustainable Agriculture, 47*(2), 210–225.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.

Schoonenboom, J., & Johnson, R. B. (2017). How to construct a mixed methods research design. *Kölner Zeitschrift für Soziologie und Sozialpsychologie, 69*(2), 107–131.

Shannon, D. K., Clay, D. E., & Kitchen, N. R. (2018). Precision agriculture technologies for crop production. *Agronomy Journal, 110*(5), 1901–1910.

Shiferaw, B., Okello, J., & Reddy, R. V. (2009). Adoption and adaptation of natural resource management innovations in smallholder agriculture. *Agricultural Systems, 102*(1–3), 112–125.

UNESCO. (2006). *Teacher training and educational development in Africa: Proceedings of the Addis Ababa education conference*. UNESCO.

Ye, Y., Zhu, Y., & Lo, C. K. (2019). Teacher competence and professional development in modern education systems. *Teaching and Teacher Education, 84*, 15–25.