



# Understanding Factors Influencing Farmers' Engagement in Watershed Management Activities

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Studies have pointed to a positive relationship between farmers' active engagement in watershed management (WM) and soil and water conservation practice adoption. If farmers' involvement in WM leads to more conservation, what predicts WM participation? This study seeks to answer that question through binomial logistic regression analysis of data from a survey of 6,006 Iowa farmers conducted to support the implementation of the Iowa Nutrient Reduction Strategy (NRS). Results indicate that public and private sector information sources, awareness of and attitudes regarding nutrient loss reduction strategies, farm contiguity to water bodies, and cost-share and technical assistance were positive predictors of farmers' engagement in WM, while lower agronomic self-efficacy, farm press as an information source, greater age, and higher farm sales were negative. Findings point to several potential actions to improve farmer involvement in WM: (1) more effectively engage with the farm press to disseminate information about the benefits of WM, (2) increase outreach to larger-scale farmers, and (3) focus on nutrient loss management capacity building. Further, a continued emphasis on awareness and attitudes related to the NRS and related actions, such as watershed management, may guide efforts to recruit farmers into watershed groups to help improve soil and water conservation outcomes.

**Keywords:** watershed management, conservation, water quality, farmers, extension

## INTRODUCTION

Loss of nutrients from agricultural fields has resulted in a greater amount of nutrients in surface and ground water resources globally (Tilman et al., 2011). Flow of nutrients through terrestrial and aquatic systems is also linked with many of the United Nation's Sustainable Development Goals (SDGs) (Ladha et al., 2020) (also see <https://www.un.org/sustainabledevelopment/sustainable-development-goals/>). Due to runoff from agricultural nutrient applications, impaired water quality has become a major concern with its associated ecological and environmental challenges (Alagele et al., 2019). In addition, excessive tillage practices have also led to soil and water degradation globally (Tilman et al., 2002; Smith et al., 2019). Implementation of strategies for reducing the use of these harmful practices while sustaining agricultural productivity at high levels is a significant priority (Tilman et al., 2011).

As states across the U.S. Midwest have struggled to meet nutrient loss reduction goals from agriculture through traditional individual-focused programs and approaches (Secchi and McDonald, 2019), watershed management groups have come to be seen as a promising strategy to catalyze effective action (Church and Prokopy, 2017). Because agriculture is the predominant source of nonpoint source pollution in the region and the main driver of harmful algal blooms (HABS) (Brooks et al., 2016), gulf hypoxia (Rabotyagov et al., 2014; Lee et al., 2018), and impaired waterways (Alagele et al., 2019), watershed management activities that actively engage farmers are of particular interest (Morton and Brown, 2011). Watershed management, which includes water resource utilization control, water pollution control, and economic policies, is an effective means of dealing with these issues at the watershed scale (Heathcote, 2009). A strong global consensus has begun to evolve that effective land and water management must start at the watershed level, and that land and water management actions must be taken in the context of watersheds and the human communities in them (Heathcote, 2009; Ramsar Convention Secretariat, 2010).

Thus, watershed management groups that strive to engage farmers have become increasingly central to water quality improvement efforts across the Midwest (Fishers Farmers Partnership, 2020; Indiana Watershed Initiative, 2020; Iowa Agriculture Water Alliance, 2020; Minnesota Association of Soil Water Conservation Districts, 2020; Natural Resources Conservation Service, 2020). Owing to the complexity of watersheds, uncertainty is one of the key factors influencing watershed management programs as successful management depends upon changes in human behaviors (Floress et al., 2015). These individual behaviors are influenced by a variety of social, economic, institutional, psychological, and biophysical attributes (Floress et al., 2015). Understanding how these factors may influence farmers' decisions to join watershed management groups is important as little is known about farmers' decisions to join such groups.

Although little research on the effectiveness of engaging farmers in such approaches exists, the few studies that have examined the impacts of farmer involvement in watershed groups point to improvements in soil and water conservation outcomes (Morton, 2008; McGuire et al., 2013; Church and Prokopy, 2017; Lee et al., 2018). Lee et al. (2018) found that farmers' active involvement in watershed management (WM) activities had strong direct and indirect relationships with their use of cover crops, a highly effective and heavily promoted nutrient loss reduction practice for farmland (Christianson et al., 2018). At the same time, however, the study found that only 27% of surveyed farmers were involved in organized watershed management activities. As recruiting farmers into watershed groups requires time, effort, money, and other resources (Church and Prokopy, 2017), improved understanding of predictors of watershed management involvement could lead to enhanced farmer participation and achievement of nutrient loss reduction goals. Given that farmer involvement in watershed management appears to lead to improved conservation outcomes, this study

asks the question: what factors influence farmers' engagement in watershed management activities?

## METHODS

### Data Collection

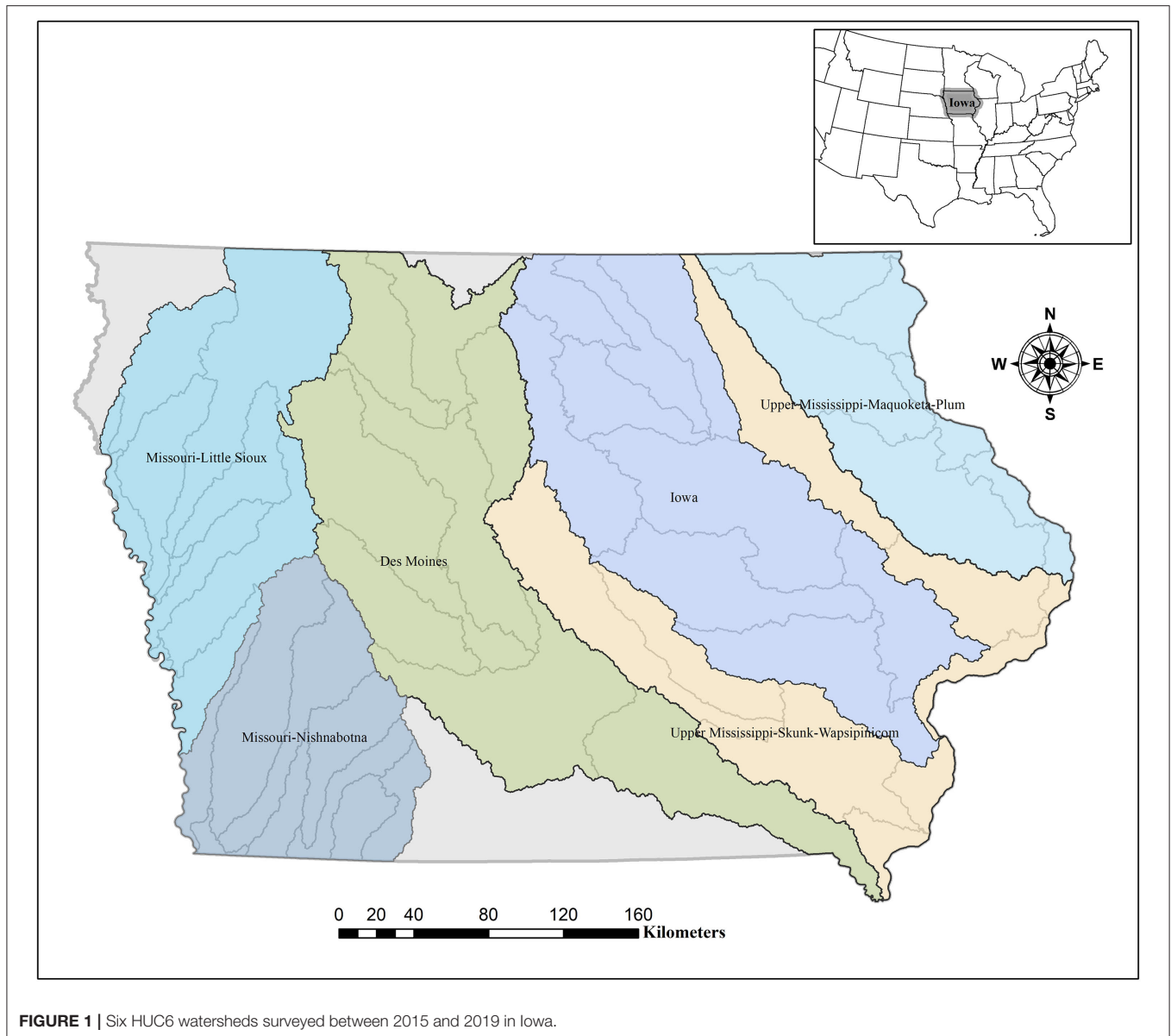
The data for this analysis were collected through a 5-year survey of Iowa farmers conducted to support the implementation of the Iowa Nutrient Reduction Strategy (NRS) (Nowatzke and Arbuckle, 2018). The NRS is a science and technology-based framework aimed to reduce nutrient loads through waterways to the Gulf of Mexico (INRS, 2017). The strategy sets a goal of reducing agricultural nonpoint and point source generated nitrogen (N) and phosphorus (P) loads by 45% in the waterways across Iowa that are transported to the Gulf of Mexico (INRS, 2020). The survey measured farmers' attitudes, behaviors, and knowledge related to nutrient loss reduction through soil and water conservation practice use. The survey was stratified by six HU6 watersheds (Figure 1) and sent to 14,139 farmers between 2015 and 2019. We received completed surveys from a total of 6,006 farmers, for a response rate of 42%.

### Variables in the Model and Data Analysis

The dependent variable is a binary measure of farmers' engagement in watershed management activities. The survey posed the question, "Are you involved in organized watershed management activities?" in the watershed where their farm operation is located. Farmers who reported involvement in watershed management were assigned 1 and 0 if not.

To guide our selection and construction of the 21 explanatory variables in the model (Table 3), we drew on two related conceptual frameworks developed to guide research to inform successful water resources management efforts. The multilevel community capacity framework, outlined by Davenport and Seekamp (2013), and the change through stakeholder engagement framework proposed by Eaton et al. (2021), both posit that research and engagement for effective watershed management should consider individuals (in this case, farmers) as embedded within multi-level social and ecological communities and their institutional and biophysical contexts. We focus on several key concepts that are common to both frameworks and also overlap with the major behavioral change frameworks diffusion of innovations and the theory of planned behavior (Prokopy et al., 2008, 2019).

First, at the individual level, we employ explanatory variables measuring farmers' awareness of watershed management activities, attitudes toward the NRS, an institutional structure promoting behavior change, and efficacy, or capacity to engage in water quality improvement efforts. Also at the individual level we include demographic characteristics such as age, education, and gender. Another set of explanatory variables focused on farmer integration into what Davenport and Seekamp (2013) term "relational networks" that facilitate knowledge sharing: the information channels through which farmers had learned about the NRS, the influence of information sources on their nutrient management decisions, and interaction with providers



**FIGURE 1** | Six HUC6 watersheds surveyed between 2015 and 2019 in Iowa.

of cost-share and/or technical assistance for conservation. A fourth set of explanatory variables measured farm characteristics, including acres of crops and pasture, percentage of cropland rented, gross farm sales, and the presence of water bodies within or contiguous to the farm.

### Individual-Level

#### *Awareness and Attitudes*

Awareness of environmental impacts related to agriculture and attitudes toward potential solutions are among the most consistent predictors of conservation practice adoption (Prokopy et al., 2019). The awareness variable (*Awareness*) is a measure of farmers' awareness of the NRS and its goals. The survey described the Iowa NRS and its goals, then asked, "Before reading

the description above, how knowledgeable were you about the Iowa Nutrient Reduction Strategy?" They were asked to answer this question through a five-point knowledge scale ranging from not at all knowledgeable (1) to very knowledgeable (5). The attitude scale (*Attitudes*) was created from four items measuring farmers' attitudes toward the NRS. Farmers were asked to rank each attitude item on a five-point agreement scale ranging from strongly disagree (1) to strongly agree (5). The scale was calculated by summing the four items, then dividing by the number of items (**Table 1**).

#### *Self-Efficacy/Capacity*

In recent years, as the Theory of Planned Behavior (Ajzen, 2002) has become a commonly used conceptual framework in

**TABLE 1** | Factor scores and reliability tests for farmers' attitudes toward the Iowa nutrient reduction strategy.

Survey items	Factor score	CARC*	KMO*	Bartlett's test
<i>Please provide your opinion on the following statements related to the NRS</i>				
<b>Attitudes</b>				
I would like to improve conservation practices on the land I farm to help meet the nutrient reduction strategy's goals.	0.746	0.731	0.759	0
Helping to meet the nutrient reduction strategy's goals is a high priority for me.	0.751			
I would be willing to have someone help me evaluate how my farm operation is doing in terms of keeping nutrients out of waterways.	0.769			
Iowa farmers should do more to reduce nutrient and sediment runoff into waterways.	0.714			

\*CARC, Cronbach's alpha reliability coefficient; KMO, Kaiser-Maier-Olkin test.

the examination of conservation practice adoption, measures of capacity to act, also termed self-efficacy, are frequently included in analyses (Reimer et al., 2012; Arbuckle and Roesch-McNally, 2015; Wilson et al., 2018). A question set assessed farmers' perspectives regarding their perceived economic and agronomic capacity to implement different practices for water quality improvement in Iowa. Farmers were asked to rank seven potential barriers to water quality improvement on a five-point agreement scale ranging from strongly disagree (1) to strongly agree (5). We created two summated scales, "Capacity.Econ" and "Capacity.Agron" which measure perceived economic capacity and perceived agronomic capacity, respectively (Table 2).

### Farm and Farmer Characteristics

We include a number of farm and farmer characteristics that are typically used in adoption studies. The farmer characteristics, age, gender, and education were included in the model (Table 3). We also include acres of cropland [*TotalAc.Crops(log)*], acres of pasture [*TotalAc.Pasture(log)*], gross farm sales (*GrossSales*), and percent of cropland rented (*PerRent.Crop*) in our model. A variable measuring whether any of the farmers' cropland bordered any water bodies such as creeks, streams, rivers, or lakes (*WaterBorder*) was also included.

### Relational Networks

#### Information Sources and Awareness

The source from which farmers receive information is a relatively consistent predictor of soil and water conservation behavior (Carlisle, 2016; Prokopy et al., 2019), and entities that raise common awareness of water issues and potential solutions set the stage for collective action (Davenport and Seekamp, 2013). We were particularly interested in where farmers received information about soil and water conservation, so we asked farmers to indicate whether they had learned about the Iowa NRS from any of eight different sources. Those eight options included: three private-sector information sources: Seed company representative, Agricultural retailer (e.g., fertilizer, agricultural chemical dealer), Independent/private crop adviser or agronomist; and three public sector information sources: Iowa State University Extension and Outreach, Natural Resources

Conservation Service (NRCS) or Soil and Water Conservation District, and another government agency (e.g., Iowa Dept of Agriculture and Land Stewardship). Lee et al. (2018) noted that these public and private sector entities had promoted the NRS through different activities such as workshops, field days, press releases, and other means of extensions. Two mass media source options were provided: the farm press (i.e., magazines, radio, TV programs, websites, that focus on agriculture) and the popular press (i.e., general-interest newspaper, TV programs, radio, magazines). We created four information source variables using a simple count of the information sources from which farmers had heard about the NRS, resulting in four-point count variables (0–3) for the private sector (*Info.Priv*) and public (*Info.Pub*) source groups and binary variables (0–1) for the farm press (*Farm.Press*) and popular press (*Pop.Press*) sources.

#### Influential Actors

Similar to information sources, different agricultural actors have been found to influence soil and water conservation behavior (Prokopy et al., 2019). For example, Lee et al. (2018) found that farmers who rated private sector actors as influential were less likely to use cover crops, while public sector entity influence was positively related to cover crops use. Our influence variables measure various stakeholders' influence on farmers' nutrient management practices and strategies. Farmers were asked to rate 14 different agricultural stakeholders on an influence scale ranging from no influence (1) to very strong influence (5). Using factor analysis, these 14 entities were grouped into four different categories, and scales were generated by summing the items' responses within each group and dividing by the number of items (Table 4). The 14 entities represent four different agricultural stakeholder groups: public sector, private sector, organizations that sponsor on-farm research and demonstrations, and family/landlords (Table 4). The public sector stakeholders (*Infl.Pub*) are NRCS or county Soil and Water Conservation District, Iowa Department of Agriculture and Land Stewardship, Iowa Water Quality Initiative (WQI), and Iowa State University Extension. Private sector entities (*Infl.Priv*) are seed companies, local agricultural retailers (e.g., fertilizer, agricultural chemical dealer, co-op), custom operator/applicator, and independent/private crop adviser/agronomist. On-farm research and demonstration groups (*Infl.On-farm*) are Practical

**TABLE 2 |** Factor scores and reliability tests for farmers' economic and agronomic capacity to implement different water quality improvement practices in Iowa.

Survey items	Factor score	CARC*	KMO*	Bartlett's test of sphericity
<i>Please indicate your disagreement or agreement with the following statements about the potential barriers</i>				
<b>Perceived economic capacity (Cap.Econ)</b>		0.777	0.7	0
I can't afford to implement more conservation practices	0.803			
Many farmers don't have the economic resources to adopt sufficient conservation practices	0.799			
There is not enough cost-share and other support available from government agencies	0.726			
Pressure to make profit margins makes it difficult to afford conservation practices	0.688			
<b>Perceived agronomic capacity (Cap.Agron)</b>		0.787	0.609	0
Nutrient loss is difficult to avoid in corn-soybean production systems	0.767			
Nutrient loss is difficult to avoid in tile-drained fields	0.756			
Many conservation practices have negative impacts on yields	0.595			

\*CARC, Cronbach's alpha reliability coefficient; KMO, Kaiser-Maier-Olkin test.

**TABLE 3 |** Descriptive statistics for the independent variables used in the analysis.

Variables	Description (scales)	Min/Max	Mean	SD
<b>Attitudes, efficacy</b>				
Awareness	Self-reported knowledge of the NRS (Knowledge)	1/5	2.948	0.966
Attitudes	Support for NRS (Agreement)	1/5	3.593	0.519
Cap.Econ	Perceived economic capacity (Agreement)	1/5	3.352	0.759
Cap.Agron	Perceived agronomic capacity (Agreement)	1/5	2.824	0.683
<b>Farmer characteristics</b>				
Age	Farmer age (Number)	20/96	57.94	11.907
Gender	Farmer gender (Male/Female)	0/1	0.979	0.14
Education	Education level (1:H.S or Less; 2:Some College; 3:Bachelors; 4:Grad School/Prof Degree)	1/4	2.046	0.971
<b>Farm characteristics</b>				
TotalAc.Crops	Log of Total Acres of Crop Land (Acres)	0/9.553	6.232	1.023
TotalAc.Pasture	Log of Total Acres of Pasture (Acres)	0/7.938	1.766	2.13
GrossSales	Gross Farm Sales None=1; <\$50k=2; \$50K-\$150k=3; \$150K-\$250k=4; \$250K-350K=5; \$350K-500K=6; \$500K-\$1000K=7; >1000K=8	1/8	5.043	1.818
PerRent.Crop	Percentage of rented crop land (%)	0/100	48.07	37.266
WaterBorder	Waterbodies border farm (Yes/No)	0/1	0.801	0.399
<b>Relational networks</b>				
Info.Pub	Public sector sources of information about NRS (Count)	0/3	1.685	1.12
Info.Priv	Private sector sources of information about NRS (Count)	0/3	0.594	0.918
Farm.Press	Farm press as sources of information about NRS (Count)	0/1	0.812	0.39
Pop.Press	Popular press as source of information about NRS (Count)	0/1	0.508	0.499
Infl.Pub	Public sector influence on nutrient management practices (Influence)	1/5	2.45	0.914
Infl.Priv	Private sector influence on nutrient management practices (Influence)	1/5	2.092	0.818
Infl.On-farm	On-farm research groups influence on nutrient management practices (Influence)	1/5	1.705	0.826
Infl.Fam	Family, peers, and landlords influence on nutrient management practices (Influence)	1/5	2.324	0.888
CS.TA	Received cost share or technical assistance for conservation (Yes/No)	0/1	0.577	0.494

Farmers of Iowa, Iowa Learning Farms, and the Iowa Soybean Association. The Family/Landlords group (*Infl.Fam*) consists of family members, landlord/farm management firm, and other farmers (Table 4).

### Cost Share and Technical Assistance Providers

Integration in conservation networks is another key predictor of conservation behaviors (Prokopy et al., 2019), as they can serve to increase farmer capacity to engage in individual and collaborative pro-environmental behaviors (Davenport and Seekamp, 2013). To measure farmer's contact with conservation-related agencies and organizations, we constructed a binary variable (*CS.TA*) from responses to the following questions: "In the last 5 years, have you received conservation technical assistance from a state or federal agency (Soil and Water Conservation District or NRCS/FSA)?" "In the last 5 years, have you received conservation technical assistance from a non-governmental organization (e.g., Soybean Association, Pheasants Forever)?" "In the last 5 years, have you received cost-share to help you fund conservation practices?" Farmers who responded "yes" to at least one of these questions were assigned a "1" and the rest a "0." More than half of the respondents (57%) reported that they had received cost-share and/or technical assistance to support conservation.

The data were analyzed using the Statistical Package for social sciences (SPSS-IBM) software, version 22, and R software (R Core Team, 2020). Due to the dependent variable's binary nature measuring participation in watershed management activities (WM), a binary logistic regression model was used (Hardle and Simar, 2014).

## RESULTS

Of 4,534 valid responses, 1,250 farmers (27.57%) reported that they were involved in watershed management activities in their area (Table 5). Our results show that 12 out of 21 variables were statistically significant at the  $p < 0.05$  level or lower. The MacFadden, Cox and Snell, and Nagelkerke pseudo- $R^2$ , three common measures of goodness of fit, were 0.15, 0.26, and 0.29, respectively, indicating that the model explains a substantial amount of variance in the dependent variable. The binomial regression model correctly classified 74% of observations, indicating a relatively good fit of the model to the data set (Table 5).

The variables measuring farmers' awareness of (*Awareness*) and attitudes toward (*Attitudes*) the NRS were positive and significant (Table 5). The odds ratio statistic indicates that a one-unit increase in the 5-point awareness and attitude scales corresponded to an increase in odds of WM engagement of 16% and 35%, respectively.

One of the two perceived capacity variables had a significant negative effect on farmers' participation in WM. The variable measuring perceived lack of agronomic capacity (*Capacity.Agron*) was significant and negatively related to farmers' participation in WM, with a one-unit increase in the scale (indicating higher perceived agronomic barriers to nutrient loss reduction) corresponding to a 13% decrease in odds of participation in WM (Table 5).

Among farmers' demographic and farm characteristics, age (*Age*) and the 8-category measure of gross farm sales (*GrossSales*) were negatively related to farmers' engagement in WM. The odds ratio statistic indicated that a one-unit increase in age corresponds to a decrease in odds of engagement in WM by 1%, and one unit increase in gross farm sales corresponds to a 6% decrease in odds of engagement in WM (Table 5). The strongest predictor among the farmer and farm characteristics was the variable measuring presence of a stream, lake, or similar water body. Farmers who farmed land bordered a water body (*WaterBorder*) were 2.02 times more likely to report participation in WM. Other farm characteristics-crop acres, pasture acres, and percent rented cropland-were not significant.

Three out of four information channels through which farmers had learned about the NRS were significant (Table 5). Learning about the NRS through public (*Info.Pub*) or private (*Info.Priv*) information sources were positively significant, with a one-unit increase in the number of the public sector and private sector sources associated with a 22% and 27% increase in odds of participation in watershed management activities. The third information channel, the farm press, was significantly and negatively related, with farmers who checked that source being 30% less likely to report engagement in watershed management activities. Popular press sources (*Pop.Press*) was not significant.

Among the four variables measuring the influence of different actors on nutrient management decisions, influence of public sector actors such as the Natural Resources Conservation Service (*Infl.Pub*) was positively related to WM. In contrast, the influence of agricultural on-farm research and demonstration groups (*Infl.On-farm*) was negative and significant, with a one-unit increase in *Infl.Pub*, resulting in a 30% increase in odds and a one-unit increase in *Infl.On-farm* resulting in a 16% decrease in odds (Table 5). Private sector entity (*Infl.Priv*) and family and landlords (*Infl.Fam*) influence were not significantly related to WM involvement.

The cost-share and technical assistance variable was the strongest predictor of involvement in watershed management activities from among the network-related variables. The coefficient for whether or not a farmer received cost-share or technical assistance to help with conservation practices (*CS.TA*) was positive and significant. The corresponding odds ratio statistic indicates that farmers who received cost share or technical assistance were more than twice (2.51) as likely to report participation in WM (Table 5).

## DISCUSSION

Establishment of watershed management groups that involve farmers has become a more common strategy in Midwestern water quality improvement efforts (Fishers Farmers Partnership, 2020; Indiana Watershed Initiative, 2020; Iowa Agriculture Water Alliance, 2020; Minnesota Association of Soil Water Conservation Districts, 2020; Natural Resources Conservation Service, 2020). This has raised interest in improving our understanding of predictors of farmers' participation in such groups. Our analysis identified 12 variables that appear to

**TABLE 4 |** Factor scores and reliability tests for different agricultural stakeholders that influence farmers' nutrient management practices and strategy decisions.

Survey items	Factor scores	CARC*	KMO*	Bartlett's test of sphericity
<i>Please indicate how much influence the following sources of information have on your decisions about nutrient management practices and strategies.</i>				
<b>Public sector (Infl.Pub)</b>		0.854	0.816	0
NRCS or county soil and water conservation district	0.834			
Iowa department of agriculture and land stewardship	0.821			
Iowa water quality initiative (WQI)	0.754			
Iowa State University Extension (e.g., field days, workshops, publications, videos)	0.753			
<b>Private sector (Infl. Priv)</b>		0.767	0.765	0
Seed company	0.826			
Local agricultural retailer (e.g., fertilizer, agricultural chemical dealer, co-op)	0.802			
Custom operator/appliator	0.753			
Independent/private crop adviser/agronomist	0.882			
<b>On-farm research groups (Infl.On-farm)</b>		0.821	0.794	0
Practical farmers of Iowa	0.848			
Iowa Learning Farms	0.821			
Iowa soybean association	0.778			
<b>Family and landlords (Infl.Fam)</b>		0.766	0.753	0
Family members	0.837			
Other farmers	0.683			
Landlord/farm management firm	0.743			

\*CARC, Cronbach's alpha reliability coefficient; KMO, Kaiser-Maier-Olkin test.

positively or negatively and significantly influence Iowa farmers' engagement in watershed management activities.

Results suggest that the type of information source from which farmers learned about the Iowa Nutrient Reduction Strategy was related to WM behavior. Much effort has gone into NRS-related outreach, with public sector actors such as university extension targeting both individual farmers and the private sector entities such as agricultural retailers that farmers rely on for agronomic advice (INRS, 2020). The results showing that farmers who learned about the NRS through public and private sector sources of information were more likely to participate in WM suggest that those efforts may have directly or indirectly influenced some farmers' decisions to join organized WM efforts. On the other hand, farmers who cited the farm press as an information source were less likely to participate in watershed management activities. A possible explanation for this may be that the farm press tends to focus articles on productivity-related themes (Walter, 1996). It is possible that coverage of conservation practices skews toward on-farm production-related practices rather than off-farm collective approaches to soil and water conservation such as watershed management. Rust et al.'s (2021) findings that farmers did not view the farm press as a credible source of information about sustainable agricultural practices, perhaps because of perceived bias toward agribusiness, support this interpretation. This may point to a need for proponents of watershed management groups to develop communication and outreach strategies that bring their work to farm press outlets' attention.

A second major finding identified associations between entities that influence farmers' nutrient management decisions and WM involvement. Farmers who attributed higher levels of

influence to public sector entities such as NRCS were more likely to report WM action. Combined with the finding that farmers who had received cost-share or technical assistance were twice as likely to be involved in WM activities, this offers evidence that public-sector groups' intensive efforts to promote conservation action positively impact farmer participation in WM. These findings align with Davenport and Seekamp's (2013) emphasis on relational and formal networks and support Church et al.'s (2019) recommendation that conservation agency involvement in watershed projects, especially combined with the promotion of cost-share and technical assistance, can play a key role in encouraging farmers' adoption of conservation practices to reduce impaired water quality.

One surprising result was the small negative relationship between influence of organizations that facilitate on-farm research and demonstration and WM involvement. Given the major role that such organizations play in promoting farmer conservation practice adoption, this result was perplexing. It may be that the specific groups that comprise the factor—Practical Farmers of Iowa, Iowa Learning Farms, and the Iowa Soybean Association—tend to focus their on-farm production and conservation practices research and demonstration work on individual farms and farmers rather than group-based watershed management. While these groups certainly support involvement in watershed groups, it could be that farmers who cite them as influential may be more focused on on-farm practices rather than off-farm, collective activities.

The strong positive relationship between farmers' awareness of the NRS and attitudes toward the strategy and its water quality

**TABLE 5 |** Binomial logistic regression of farmers' participation in watershed management activities on selected variables.

Variables	Coefficient	SE	Z	Odds ratio	P-value
(Intercept)	-3.667	0.594	-6.175	0.026	0.000
<b>Attitudes, efficacy</b>					
<i>Awareness</i>	0.151	0.045	3.4	1.163	0.001
<i>Attitudes</i>	0.302	0.078	3.889	1.353	0.000
<i>Cap.Econ</i>	0.027	0.05	0.55	1.028	0.583
<i>Cap.Agron</i>	-0.14	0.056	-2.513	0.869	0.012
<b>Farmer characteristics</b>					
<i>Age</i>	-0.009	0.003	-2.605	0.991	0.009
<i>Gender</i>	0.433	0.294	1.474	1.541	0.141
<i>Education</i>	-0.066	0.038	-1.721	0.936	0.085
<b>Farm characteristics</b>					
<i>TotalAc.Crops(log)</i>	0.008	0.062	0.136	1.008	0.892
<i>TotalAc.Pasture(log)</i>	0.013	0.107	6.576	1.013	0.441
<i>GrossSales</i>	-0.056	0.017	0.771	0.945	0.053
<i>PerRent.Crop</i>	0.001	0.029	-1.927	1.001	0.536
<i>WaterBorder</i>	0.706	0.001	0.619	2.025	0.000
<b>Relational networks</b>					
<i>Info.Pub</i>	0.195	0.038	5.09	1.215	0.000
<i>Info.Priv</i>	0.235	0.04	5.838	1.265	0.000
<i>Farm.Press</i>	-0.346	0.102	-3.406	0.707	0.001
<i>Pop.Press</i>	-0.006	0.076	-0.074	0.994	0.941
<i>Infl.Pub</i>	0.26	0.058	4.481	1.297	0.000
<i>Infl.Priv</i>	-0.03	0.054	-0.558	0.97	0.577
<i>Infl.On-farm</i>	-0.165	0.057	-2.885	0.848	0.004
<i>Infl.Fam</i>	0.054	0.049	1.104	1.056	0.27
<i>CS.TA</i>	0.921	0.082	11.258	2.511	0.000
MacFadden Pseudo $R^2$	0.148				
Cox and Snell (ML) Pseudo $R^2$	0.256				
Nagelkerke (Cragg and Uhler) Pseudo $R^2$	0.297				
Correct prediction %	0.739				
<i>n</i>	4,534				
WM Participant (%)	27.57				
Non-Participant (%)	72.43				
Model $\chi^2$	577.3				0.000

improvement objectives and their engagement in watershed management action is encouraging. A central tenet of the Iowa NRS is that efforts to increase awareness and change attitudes will lead to behavior change. These results, which align with our conceptual frameworks and previous research (Prokopy et al., 2019), suggest that, at least in terms of farmer involvement in WM, the focus on shifting awareness and attitudes may be effective.

Another result that we wish to highlight is the negative relationship between the agronomic capacity variable and involvement in watershed management. Results show that farmers who reported a lower perceived capacity to reduce nutrient loss in their cropping systems were less likely to engage in WM activities. This finding is important because watershed groups that involve farmers often focus on helping them to surmount their perceived capacity barriers through peer-to-peer

learning and other assistance (Morton, 2008; McGuire et al., 2013). Thus, this result indicates that watershed management groups and other stakeholders should continue to focus on increasing farmer confidence in their capacity to address nutrient loss, and specifically take self-efficacy challenges into account in farmer WM recruitment efforts. These findings and recommendations align with those suggested in previous studies (Arbuckle and Roesch-McNally, 2015; Burnett et al., 2018; Lee et al., 2018).

Another negative predictor of involvement in WM activities that requires discussion is gross farm sales. Farm sales is a proxy of farm size, so the result indicates that larger-scale farmers may be less likely to become involved in watershed management. Because larger-scale operations farm a disproportionate amount of land relative to their numbers (USDA ERS, 2020), their engagement in soil and water conservation efforts is critically



important. Efforts to bring more larger-scale farmers into WM and similar conservation efforts should be increased.

Finally, the result indicating that farmers whose farm operations were bordered or bisected by streams and other water bodies were twice as likely to be involved in WM has major implications for outreach. This finding suggests that watershed planning efforts that employ GIS, remote sensing, modeling, and innovative tools such as the Agricultural Conservation Planning Framework to facilitate watershed-level conservation planning and action (Ranjan et al., 2019) may find such farmers to be more receptive to targeted outreach.

## CONCLUSION

Despite major financial and other investments in individual-focused traditional programs and approaches, agricultural production practices across the U.S. Midwest still lead to major environmental challenges, including harmful algal blooms (Brooks et al., 2016), gulf hypoxia (Rabotyagov et al., 2014), biodiversity loss, and impaired waterways (Alagele et al., 2019), and nutrient loss reduction goals are far from met (Secchi and McDonald, 2019). As individual-focused programs have faltered, voluntary collective actions such as watershed management groups have become increasingly central to water quality improvement efforts across the Midwest (Church and Prokopy, 2017). In most agricultural regions, farmers manage the majority of the land, and how they manage it largely determines watershed health. Because farmers' engagement in watershed management appears to directly or indirectly affect the adoption of key practices (McGuire et al., 2013; Lee et al., 2018), results presented in this paper can serve to inform ongoing and increasing efforts to involve farmers in WM activities.

Our findings have broad relevance given the increasing role that watershed management planning and action plays in working toward improved water quality, which in turn makes a vital contribution to social, economic and ecological benefits and services. Diverse countries including the U.S. have agreed upon goals like the United Nations Sustainable Development Goals (SDGs) in an integrated manner (see <https://www.un.org/sustainabledevelopment/sustainable-development-goals/>). Policy and decision-makers are increasingly looking for policy options that will help them achieve these agreed upon goals (McElwee et al., 2020). It is suggested that many land challenges such as clean water and sanitation (SDG 6), Life under water (SDG 14) and Life on land (SDG 15) can be met with a range of response options readily available, such as reducing the alteration of natural ecosystems and increasing adoption of conservation practices that reduce nutrient loss to surface water (McElwee et al., 2020). Our study, by identifying factors associated with farmers' participation in watershed management activities, can

also assist decision-makers to craft policy and goals setting for achieving different SDGs including SDGs 6, 14, and 15.

In summary, this research points to several key levers to help increase farmers' involvement in watershed management activities. Specifically, it highlights the importance of engaging with the information sources and influential actors that can be related to farmer proclivity to take part in WM, as well as the critical role that awareness of water quality issues and attitudes toward amelioration efforts can play. Extension and outreach efforts should continue to focus on raising awareness and attitudes and further align information sources and influential actors, including watershed groups themselves, on working to recruit farmers into watershed management groups and collective efforts to improve water quality.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because our Institutional Review Board human subjects research protections make it difficult to share primary survey data. Requests to access the datasets should be directed to J. Gordon Arbuckle, [arbuckle@iastate.edu](mailto:arbuckle@iastate.edu).

## ETHICS STATEMENT

This research involving human participants was reviewed and approved by the Iowa State University, Institutional Review Board (IRB).

## AUTHOR CONTRIBUTIONS

SU and JA conceived the idea for the manuscript and wrote the manuscript. JA designed the survey and collected the data. SU conducted the data analysis. All authors contributed to the article and approved the submitted version.

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The reviewer PB declared a past co-authorship with one of the authors SU to the handling editor.

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