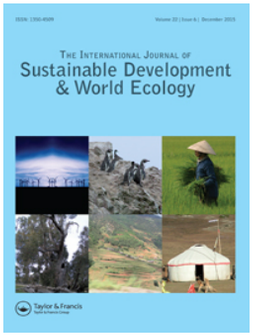

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Explaining and understanding environmental actions in Chinese agriculture: the case of Yuqiao watershed of Tianjin municipality

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Most of China's surface waters are undergoing anthropogenic eutrophication, mainly due to leaching of phosphorus (P) from both sewage and agriculture. This is causing quality deterioration in their scarce water resources. The problem has been acknowledged by Chinese authorities and actions sought implemented, though expected ameliorations are on hold.

This interdisciplinary study focuses on actions taken by farmers adjacent to Yuqiao reservoir; the raw water source for five million people in Tianjin City. As is often the case, these farmers apply excessive amounts of fertilisers. The leaching of P is aggravated by poor P sorption capacity of the soils and a practically impermeable clay layer below a shallow ploughing layer. During heavy rainfalls the soils become saturated, causing P to be flushed out through shallow-water flow paths. A low content of organic matter in the soils makes things worse.

This study documents how farmers are taking action to improve crop yield, the environment, and health issues. Farmers taking more action than others consider themselves as having good farming competence, they are usually local members of the Chinese Communist Party (CPC), and have a relatively low family income. The study concludes with suggested policy measures. The main recommendation is to collect household sewage and most of their manure and use it as feedstock for large-scale biogas reactors, combined with returning the residual organic matter to the soil. Cooperating with well-respected farmers and drawing on local CPC members' willingness to take action may facilitate a successful implementation of the above measures.

Keywords: environment; value; action; policy; agriculture; eutrophication; phosphorus; China

Introduction

The challenges of taking environmental actions and not just talking about it have for decades been centre stage of environmental studies. True, many abatement actions have been taken by authorities as well as by individual actors, but inadequate abatement actions and other actions causing further environmental degradation are still prevalent. This is the case in China, a country that during the last 30 years has become the manufacturing powerhouse of the global economy and today is facing a multitude of environmental challenges. As in Western countries, Chinese authorities started issuing a series of laws and regulations in the 1970s, addressing pollution issues and advocating environmental protection. This was enhanced after the turn of the century and most recently by an updated and amended Environmental Protection Law. Many and diverse concrete environmental abatement actions have also been conducted during the past 60 years in the Peoples' Republic of China. Despite such commitments and substantial efforts, China's natural regional environment has experienced increasing stress, with the need for stronger action becoming more evident during the last two decades. However, China has a fundamental problem in regard to the lack of enforcement and willingness to comply with the existing environmental legislation (CCICD. 2006, Harris 2008b). Therefore, the challenges currently facing China demand all-out effort for different types of pollution to be curbed and abated, thereby bringing the development onto a more sustainable path and realising the ideal of 'beautiful China' (Ke 2013), along with making the country 'moderately prosperous' according to the current leadership (President Xi and Premier Li).

In short, actions from the local to the national and beyond are necessary, and not only actions; it might also be argued that adequate environmental values are necessary for proper actions to be taken as well (Harris 2008a). Therefore, we argue that explaining and understanding environmental behaviour (values, attitudes, and actions) in China is a prerequisite for ensuring feasibility of abatement actions. Studies of environmental actions have had a strong focus on purchasing and consumption patterns in regard to energy saving, water conservation, recycling, and more generally green consumption, as exemplified by Barr (2008) and also by studies on China (e.g. Li

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2003; Chen et al. 2011; Feng & Reisner 2011). Our focus, on the other hand, is on environmental behaviour in Chinese agriculture, in the sector of family farming, and we are building on a previous analysis of environmental values and attitudes prevalent among the same group of farmers (Orderud & Vogt, Forthcoming 2015).

The raison d'être to study farmers is, first, that eutrophication due to diffuse loss of nutrients from fertilised fields and manure from husbandry is the main cause of deteriorating water quality in China's freshwater lakes. Second, by studying farmers we are addressing environmental actions on the production side. Third, as this is embedded in the household, we bring the actions down to the local scale and efforts taken by individuals in local communities. Moreover, the analysis contributes to the study of rural environmental protection, a field that is not given enough attention according to Xi et al. (2015).

The scientific literature on agricultural practices has been discussing a claimed move from productivism to post-productivism (see Wilson 2001 for a review): that is, a transition to a more environmentally sound type of farming. However, Burton and Wilson (2006) conclude that farmers are dominated by production-oriented identities, a conclusion supported by our own research in Norway (Orderud & Vogt 2013; Barton et al. 2015). Reviewing the literature on demographic factors such as age, gender, education, and experience, Burton (2014) concludes that the observed inconsistencies regarding environmental actions may pertain to a lack of understanding of the complex and contradictory character of the causality of these factors. Moreover, several studies have underlined the governing role of practical knowledge, skills, abilities, personal experience, prior opinions, and environmental constraints and biospheric values (e.g. Vogel 1996; Andrews et al. 2013; Price & Leviston 2014), thereby highlighting context and the role of practical learning and knowledge (formal and by doing). This is also evident from our own research in Norway (Orderud & Vogt 2013; Barton et al. 2015). Similar studies are needed in China. The study presented below aims at contributing to this through the case of eutrophication, by analysing environmental values regarding different categories of environmental actions related to farming and the local community. The main research questions asked were:

(i) What are the main demographic and socio-economic factors – as well as environmental values and attitudes – that explain the differences among farmers in regard to the extent to which they take actions?
(ii) Is the predominance of pro-environmentalist values among farmers (Orderud and Vogt, Forthcoming 2015) materialising in actions of environmentally sound farming practices?
(iii) In reference to an analogous study among Norwegian farmers, are there any similarities in values, attitudes, and actions, thereby making any lessons from Norway useful in a Chinese context?
(iv) Finally, which implications pertaining to agricultural and environmental policies in China can be drawn from the study?

The study presented in this paper is firmly embedded in the field of large interdisciplinary research, combining both natural and social sciences and transdisciplinary processes. Moreover, we fully acknowledge the importance of social and community values, and taking into account social, political, and ethical factors when studying environmental issues. As such, our study adheres to the basic principles of ecological economics (e.g. Spash 1999; Baumgärtner et al. 2008; Costanza et al. 2008). Adopting this approach also has implications for any consideration of policy measures. Simply resorting to economic incentives (whether negative or positive) most probably misses important dimensions of any policy design for sustainable development.

Theory, methodology, and empirical basis

Theory

The Chinese government has taken a firm stand in favour of sustainable environmental development in order to ensure continuing growth in gross domestic product (GNP). The 'quality growth' emphasised in China's 12th Five Year Plan (FYP), with 'scientific development' at its core, promises to shift China's focus from unbridled economic expansion to a model which delivers green growth and social stability, and slows GDP growth rate to a target level of 7% (China Water Risk 2011). A number of studies have tried to explain the failure in abating environmental degradation in China by inadequate enforcement capacity, and ability and willingness to comply (e.g. Ross 1992; Rozelle et al. 1997; CCICD. 2006; Harris 2008a; OECD 2006; Zhou & Sheate 2011; Wang et al. 2011). Nevertheless, it remains a paradox that the Chinese leadership, which is capable of implementing strong abatement actions such as the one-child policy in order to ensure sustainable development, is unable to deal successfully with the problem of water pollution (Khan & Liu 2008), which is currently aggravating a severe water shortage in northern China. Clearly, the top priorities of high economic gain and sustaining growth are in conflict with aims of curbing emissions of pollutants to the air, soil, and water. However, the presumption made in this study is that there is a more complex set of factors and processes that is resulting in poor compliance with regulations. The environmental problems are thereby allowed to continue and increase through a combination of structure and agency. It is generally considered that the Chinese 'party state' allows the government to take unpopular, yet correct in the long term, decisions without the prospect of losing its dominance in the next election, as is the case in representative democracies of the West. Nuancing this picture, Eaton and Kostka (2014) describes how the institutionalised rotation system of party cadres of the CCP facilitates 'short-termism', with the tendency to disregard environmental problems because these generally demand long-term efforts and cannot easily be used

instrumentally for promotional aims. However, a recent strengthening of top-down policies favouring the environment may yet prove key in helping counterbalance this short-termism. Nevertheless, environmental actions are fundamentally grounded on grassroots practices and actions, with some (categories of) people taking more actions than others. Both structure and agency thus need to be assessed in order to identify the important drivers and pressures, as well as to understand the mechanisms governing actors' environmental behaviours and actions.

Turning to theories within the field of environmental behaviour, the information deficit model, advocating causal links among awareness–information–decision–action, has played a prominent role. The 1962 book *Silent Spring*, by Rachel Carson, spurred a paradigm shift in Western awareness of indirect harmful consequences to our environment as a result of our actions. Linking failure to comply with lack of knowledge also represents a positivist approach of rationalism based on scientific truths. Gross (1994, p. 19) denounced this as 'casting the public in a passive role [...] mask[ing] the ethical and political implications of science'. Instead, Gross proposed the contextual model, bringing to the forefront environmental actions as being 'the joint product of scientific and local knowledge' and 'an interaction between the public and the science'. Another approach to assessing environmental behaviour and action is the Theory of Reasoned Action (Fishbein & Ajzen 1975), singling out intentions based on attitudes and subjective norms as guiding actions. This was then developed into the Theory of Planned Behaviour (Ajzen 1991), by taking into account that intentions and actions could be guided by perceived behavioural control; that is, 'people's perception of the ease or difficulty of performing the behaviour of interest', which is assumed to reflect past experiences (Ajzen, 1991, p. 183). Barr (2007, 2008) takes these approaches even further by arguing that 'links between household attitudes and environmental behaviours [...] can broadly be attributed to three groups of independent variables: environmental values, situational variables, and psychological factors' (Barr, p. 436). Together these three groups form behavioural intentions which lead to specific behavioural patterns. However, both situational variables (context, experience, socio-demographics, and environmental knowledge) and psychological factors (motivations and mental thresholds) influence behaviour directly, thereby entailing agency–structure interactions.

Our analysis builds on the approach formulated by Barr (2007, 2008), taking into account variables covering environmental values, situational variables, and psychological factors but with a focus on the first two categories. We start by laying out the contextual variables of the situational dimension as a framework for the analysis of farmers' environmental actions. The importance of experience, socio-demographics, and environmental knowledge, as well as environmental values (and attitudes), is then tested.

Reviewing studies on environmental values in China, Harris (2008a) concluded that although environmental knowledge was superior among younger and well-educated Chinese city dwellers, developing a policy for a sustainable environment demanded a change in attitudes; that is, it required building environmental values. Nuancing the review by Harris, Feng and Reisner (2011) found that environmental knowledge was also present among rural residents, as well as those with lower education. Moreover, Wang and Reisner, distinguishing between private (within the household and with private gains) and public environmental protection actions (advocacy actions with no direct private economic benefit), found that both environmental knowledge and pledging support for environmental protection were important for spurring actions within both private and public protection. Among the set of traditional demographic variables, the study by Wang and Reisner identified only gender as an explanatory variable for environmental protection of the private type. Specifically, Li (2003) found that women were doing most of the recycling due to their doing the majority of household work, and that this held true across different levels of both age and education. Li also found that the poor elders of both genders were doing more recycling: i.e. those who had grown up in times of scarcity. Chen et al. (2011) confirmed the role played by females, but also added that those with a new ecological paradigm (NEP) world view, being young, highly educated, holding leadership positions, and living in larger cities, were more likely to take actions (e.g. sorting garbage, recycling bags, environmental talks, environmental litigation, environmental volunteering). Chen et al. (2013) pointed out that those experiencing environmental harm had stronger pro-environmental attitudes and were taking more actions. On the other hand, studies have found that although local residents (i.e. farmers and others, also migrant labour in low-tech manufacturing industries) are well aware of environmental problems and negative consequences of their own or others' actions on their health, their economic dependence might mute any serious change in behaviour (Tilt 2010, 2013; Deng & Yang 2013). This might take place without any changes in environmental attitudes, but also that pro-environmental attitudes may be muted due to economic dependence.

Around the year 2000 an ecological focus on stocks and flows of natural resources developed into payment for ecosystem services (PES) as the new trendy policy measure for managing resources. Norgaard (2010) is critical towards this use of stock–flow approach because it leaves out important dimensions of ecology and also faces challenges of transferring insight from one case to others; that is, contextuality demands 'relationships between services and ecosystem states (need) to be determined for each location' (p. 1221). The data gap underlined by Wong et al. (2015)[1] addressing the use of ecosystem services in China resembles Nordgaard's contextual factor. However, Norgaard (2010) also points out that PES is commonly

part of individual project analyses and is based on assumptions of partial equilibrium assuming all other things being equal (*ceteris paribus*). This means that changes potentially bringing the general economic system onto a more sustainable trajectory are left out. Chen et al. (2009), studying re-enrolment to a 'grain-to-green' programme in Wolong Nature Reserve in China's Sichuan Province, found that farmers based their decision on a variety of factors. For one thing, farmers considered how much land that was already enrolled by neighbours in their village before deciding to join. If much land had already been enrolled in the programme, other farmers would be reluctant to come forward.[2] Moreover, high PES payments and/or low income from farming increased the likelihood of enrolment, while off-farm work decreased the propensity to join the programme. Zheng et al. (2013), studying a policy of 'paddy land-to-dry land' in the upstream sections of the Miyun reservoir watershed north of Beijing, found a very high re-enrolment rate among the farmers taking part in this programme (half of the farmers targeted took part in the programme). Farmers that joined the programme were more inclined to find work outside farming, and that re-enrolment was more likely among those households that were earning the most from off-farm work. Even though dry land production increased the usage of fertilisers, the authors claim this change in land use led to less leaching of nutrients than for paddy rice cultivation. Moreover, the change also resulted in lower water consumption, leaving more water for the Miyun reservoir (the ecosystem service).

Although favourable to the PES instrument, both Chen et al. (2009) and Zheng et al. (2013) showed how a PES system interacts with other factors by initiating processes impacting on the outcome of the payments made for the identified and chosen ecosystem services, thereby illustrating the deficiency of partial equilibrium approaches underlined by Norgaard (2010). The study presented in this paper acknowledges the demands for and challenges of context, and the demand for presenting a holistic basis for policy making.

Methodology and empirical basis

The data used in the analysis of this study were generated through a survey (conducted in spring 2012) with closed questions in 11 agricultural villages in Ji County of Tianjin Municipality. This is the local watershed of the Yuqiao drinking water reservoir for the 6.5 million residents of Tianjin city. The study was conducted as part of a larger interdisciplinary Sino-Norwegian research project[3] on the natural and social factors governing eutrophication and barriers in society towards abatement actions. In total there are about 150 villages in this area, consisting of a few hundred to about two thousand residents. The 11 villages in the sample were chosen to cover two transects, spanning from west to east along the shore of the reservoir and from south to north along the main valley. Furthermore, the villages covered dominant crops (wheat, corn, vegetables, and orchards) and various husbandries (pig farming and fish farming). In total, 545 respondents participated, with about 50 respondents from each village. Further respondents attended in large villages and a few more in small villages.[4] Four graduate students from Tianjin conducted the practical aspects of the survey after training, but still guided by responsible researchers. The training enabled the students to respond to enquiries from respondents and to actively monitor the farmers filling in the questionnaires. This improved the reliability of the data.

The sample is not representative regarding, e.g. gender, with more women than men. However, with about a quarter of the sample are men, this allows the inclusion of gender as an independent variable in the multivariate analyses. The sample had a fairly good distribution in regard to age and education level.[5] About 35 questionnaires were left out of the analysis due to unreliable scoring – e.g. top scores on all questions or on central questions for the analysis, thereby disclosing systematic inconsistencies in responses. The respondents were members of farming families and 60% of them (N = 443) claimed to be the one to take decisions on the usage of fertilisers, whereas 33% replied that it was a family decision. Of the remaining 7%, farmers in the village accounted for 5% whereas 1% named a village committee or county officials. Consequently, most of the respondents are involved in the decision regarding fertiliser usage.

The statistical analysis is based on quantitative methodology, with a multivariate analysis using linear regression models.[6] The dependent variable of actions taken was transformed from binary to numerical format. Likewise, several of the independent variables formulated as questions with six- (or five-)point Likert scales were transformed into numeric variables.

The context

A strong economic growth has been and still is an overarching aim of the Chinese national policy. Moreover, national targets for food production are being worked out, underlining the importance of food security at the national level. This is clearly reflected in the national policies towards rural areas – i.e. the Socialist Countryside policies of the previous President (Hu Jintao), as well as the agricultural modernisation dictated in the policy of Four Modernizations,[7] launched by the current Premier (Li). The recently formulated Urbanisation Strategy is aimed at increasing urbanisation from just over 50% today to some 70% by 2030. This will cause changes not only in urban but also in rural areas. The Yuqiao watershed is situated at the outskirts of the Beijing–Tianjin urban region, with access therefore to large urban labour markets without farmers having to leave the family behind for long spans of time, thereby offering a convenient alternative income to farming.

Turning to the characteristics of the watershed, this is a human transformed landscape with the reservoir itself

being an engineered dam. It is thus a generic part of the China described by Elvin (2004, p. 5) as:

> . . . multi-millennial transformation of a variety of habitats by some version of the Chinese style of settlement: cutting down most of the trees for clearance, buildings, and fuel, an ever-intensifying garden type of farming and arboriculture, water-control systems both large and small, commercialization, and cities and villages located as near the water's edge as possible.

The agricultural practice that came into existence at the beginning of the twentieth century was characterised by recycling of all available nutrients, as described by King (1927, p. 25):

> Almost every foot of land is made to contribute material for food, fuel or fabric. Everything which can be made edible serves as food for man or domestic animals. Whatever cannot be eaten or worn is used for fuel. The wastes of the body, of fuel and of fabric are taken back to the field; before doing so they are housed against waste from weather, intelligently compounded and patiently worked at through one, three or even six months, in order to bring them into the most efficient form to serve as manure for the soil, or as feed for the crop.

In the local Yuqiao watershed there are about 130,000 residents, living mainly off farming consisting of livestock (mainly chicken, pigs, and fish) husbandry and grain and vegetable production (Joshi 2014). The total annual phosphorus (P) loading from sewage and manure in the local watershed is about 73 and 365 tons, respectively. In recent years, the use of human sewage has decreased due to the introduction of water closets by an increasing number of families, making the sewage less usable as a fertiliser. Moreover, due to increased labour costs the usage of both sewage and manure as organic fertiliser has declined. Nevertheless, due to a lack of any useful end product, effluent sewage and dung is instead simply disposed of in the landscape and likely ends up in the Yuqiao reservoir. Nutrients are flushed out during episodes of heavy rainfall. In addition, on a larger scale, mineral fertilisers have been introduced to Chinese agriculture. According to Zhou et al. (2014), the local environmental protection bureau reported that the application of excessive amounts of inorganic P fertilisers and discarding of livestock manure are general practice in this region. With no idea of the soil's poor P sorption capacity, locals add approximately 9 g of P per square meter of agricultural land, which is about five times more than that commonly applied in countries such as Norway.

These nutrients are readily flushed out due to the poor P sorption capacity of the soils (Pettersen 2014). Moreover, the soils are rich in clay, with a predominance of non-swelling 1:1-type clay below the plough layer. This makes the soil profile practically impermeable to water. Rainwater is thus only stored in the rather shallow (<30 cm) plough layer, which thus quickly becomes saturated during heavy rainfall, triggering water flow paths over the surface or sub-laterally through P-rich soil, flushing large quantities of P into the lake (Ojwando 2014; Zhou et al., accepted).

The analysis

Operationalisation of variables and formulation of working hypotheses

The dependent (or response) variables of this assessment are 11 potentially good agriculture management practice actions conducted within the last five years. Table 1 lists the actions and presents the multi-response statistics, showing that between 33% (tidying fields and home/village) and 59% (improving product quality) of the respondents claim to have conducted specific actions. Except for the tidying action, the extent to which farmers have conducted the different actions is similar: five actions were in the range 50–59% and five between 40% and 46%.

Table 1. Summary of responds to the question: Have you during the last five years made any efforts in regard to the following actions?

		Responses[1]		
#	Actions	*N*	Percentage of total	Percentage of cases[2]
1	Making fields and home/village more tidy	159	6.2	32.7
2	Improving the quality of the products you are producing	286	11.2	58.8
3	Improving health conditions for your livestock	245	9.6	50.4
4	Improving production techniques, saving input of labour	267	10.5	54.9
5	Increasing the output of your farming	276	10.8	56.8
6	Increase the price of your products to buyers	200	7.8	41.2
7	Introducing better storage of manure, with no leakages	216	8.5	44.4
8	Improving your usage of manure and mineral fertilisers, make it more efficient	212	8.3	43.6
9	Reducing usage of mineral fertilisers	207	8.1	42.6
10	Reducing usage of pesticides	225	8.8	46.3
11	In general, improving sanitation systems and handling of waste water and waste	260	10.2	53.5
	Total	**2553**	**100**	

Notes: [1]*N* denotes how many respondents scored each action; note that each respondent may have marked more than one action, giving to a total of 2553 scores. The 'percentage of total' is the share each action constituted of total markings.
[2]'Percentage of cases' gives the share of respondents (cases) who scored each action, and 535.3 is the sum of the percentage points for all actions.

Based on the nature of the 11 actions, the *dependent* variables were combined into four action response variables (A–D), summarising the scores for a number of actions, and were used in the multivariate analysis:

(A) Total environmental actions: all 11 actions
(B) Production-oriented actions: the sum of action 2 (improving the quality of the products you are producing); action 4 (improving production techniques, saving input of labour); action 5 (increasing the output of your farming); and action 8 (improving the use of manure and mineral fertilisers, improving efficiency).
(C) Environmentalist actions: comprising action 3 (improving the health of your livestock); action 7 (introducing better storage of manure, with no leakages); action 9 (reducing usage of mineral fertilisers); and action 10 (reducing usage of pesticides).
(D) Clustered actions: comprising action 6 (increasing the price of your products to buyers); and actions 8, 9, and 10.

The *independent* (or explanatory) variables can be subsumed under Barr's headings, as follows (detailed presentation of the variables is provided in Annex 1):

Environmental value/attitude variables:

(1) The New Ecological Paradigm Scale (Dunlap et al. 2000)[8]:
  (a) NEP world view statements.
  (b) Dominant Social Paradigm (DSP) world view statements.
(2) Important aspects of agricultural production:
  (a) Pollution of soil and of water.
  (b) Tidiness and status.
(3) Farming motives:
  (a) Production and economic motives.
  (b) Health and environment motives.
  (c) Farmers' status and tidiness motives.

We tested the following hypotheses, based on work by Chen et al. (2011), Harris (2008a), Feng and Reisner (2011), and Dunlap et al. (2000), claiming a link between environmental values and environmental actions: the NEP world view (1a), concern over pollution from farming (2a), and health/environment motives for farming (3b) will support environmental actions; whereas the DSP world view (1b) and production-economic motives for farming (3a) will support production oriented actions.

Situational variables:

- Socio-demographical variables:
  (i) age; (ii) gender; (iii) education
- Socio-economic variables:
  (i) family income; (ii) village poverty rate; (iii) jobs outside farming; (iv) membership of the CPC; and (v) self-reported social status.
- Farming experience/knowledge:
  (i) self-reported competence in farming; (ii) received instructions on the use of fertilisers/P; and (iii) contact frequency with other farmers, village committee, supplier firms, etc.
- Environmental knowledge:
  Knowledge on impacts (environmental/production) of using fertilisers/P.

Due to a lack of any clear and concise causal reasoning, the literature on empirically funded explanatory socio-demographic variables governing environmental behaviour (values and actions) remains somewhat unclear. It is possible that the identified variables are mere proxies for unidentified underlying socio-demographic drivers, or that they are simply co-varying with some of the explanatory factors listed above.

Hypothesis: The Chinese studies referred to above nevertheless indicate that being female, being young, and having a high level of education are linked to pro-environmental values/attitudes and to certain types of action. The working hypothesis is therefore that females, the young, and the highly educated will take more environmental actions rather than production-oriented actions.

Regarding the socio-economic variables the ambiguities are even stronger: the poor are doing more recycling, but at the same time more affluent farmers are at liberty to take more actions, pertaining to the theory behind the Kuznets curve (Shafik & Bandyopadhyay 1992).

Xiao et al. (2013) found that members of the CPC expressed stronger environmental concern than others, and from this we might hypothesise that they may attempt to follow up on national policy aims of improving the environment, while concurrently also trying to meet goals of economic growth which are often inherently in conflict with environmental protection. We expect high self-reported social status to support taking actions in general, although not necessarily more environmental actions.

Regarding farming experience and environmental knowledge, the variables of self-reported competence and contact frequency are expected to increase production-oriented actions while being neutral regarding environmental actions. On the other hand, having received instructions on the use of fertilisers, together with knowledge of the environmental impacts of excess application of fertilisers, is expected to increase environmental actions.

Psychological variables:

(1) Location-specific:
  (i) pro-local sentiments; (ii) anti-local sentiments; and (iii) living in the village or moving away.

Hypotheses: It is generally conceived that residents with pro-local sentiments and preferences for staying in the area are prone to take more actions of all types, whereas persons with anti-local sentiments and a desire to move are less inclined to take actions.

In addition, self-reported social status and self-reported farming competence may *indirectly* entail something about motivators and barriers, in addition to being part of the situational variables listed above.

The multivariate analysis approach and results

The multivariate analysis was conducted using linear regression, with a combined hierarchical–stepwise approach on respondents' scoring on the four dependent variables listed above (A–D). Two main categories of explanatory variables were used:

- *Category 1*: Situational variables covering socio-demographics and socio-economics (age, gender, education, income, jobs outside farming, village poverty, self-reported social status and CPC membership)
- *Category 2*: Environmental value/attitudes variables; situational variables, covering environmental knowledge, farming experience and knowledge; and psychological variables.

The first hierarchical model (Model 1) comprises Category 1 variables while the second hierarchical model (Model 2) potentially comprises variables under Category 2. The procedure for determining which of the independent variables under Category 2 were to be included in Model 2 was as follows.

Each of the variables in Category 2 was individually tested statistically against the first category of variables (Model 1), and those variables that proved to be significantly independent were included in Model 2. As is evident from the tables below, several of the variables thereby included in Model 2 were not statistically significant when combined with the other independent variables.

No strong positive correlation coefficients (i.e. $r^2 > 0.3$) were found between the independent variables, thereby ruling out any possible distortion of the multivariate regression analysis. The Durbin–Watson coefficient is close to 2 for the analysis of the four dependent variables (A–D), indicating good reliability of the data. The results from the multivariate analysis can be summarised as follows:

- 'Social status' (self-reported) appears as positive, and thus explanatory under Model 1 (situational variables) for all four dependent action variables, but was not significant for any of them under Model 2 when environmental related variables were added.
- 'Farming competence' (self-reported) is a positive factor for conducting actions, and the most important variable in Model 2 for all four dependent action variables.
- 'CPC membership' was positive for three of the dependent action variables under Model 1; and A, B, and D, but not C (environmental actions) and for all four action variables under Model 2.
- 'Instructions about use of fertilisers' are positive for all four dependant action variables under Model 2.
- 'Family income' appears as a negative force under Model 1 for All actions (A) and in Model 2 for All actions (A), Environmental actions (C), and Clustered actions (D). The size of the coefficient for All actions and Environmental actions is not significantly different.
- 'Concern regarding pollution from farming' (2a) appears as positive in Model 2 for Production-oriented actions (B).

Within this overall frame, we can add the following:

- 'Farming competence' (self-reported) has its strongest explanatory value for All actions (A)' followed by Production-oriented actions (B) and Environmental actions (C).
- 'CPC membership' is strongest for All actions (A), then Environmental actions (C) and Clustered actions (D).
- 'Instructions on fertiliser use' has an equally strong regression coefficient for All actions (A) and Production-oriented actions (B), followed by Environmental actions (C).
- 'Family income' has a similar correlation coefficient to All actions (A) and Environmental actions (C).

Moreover, from this we can deduce the following:

- Except for the concern over 'Pollution of soil and water' from farming' (2a), none of the other environmental value/attitude actions moved beyond the first stage of the procedure outlined above: that is, they did not prove significant when tested individually together with variables in the first category (Model 1).
- The following variables, which were included in Model 2, were not found to be statistically significant: 'Knowledge on impacts of using fertilisers' and 'Contact frequency'; the two farming motives variables of 'Health/environment' and 'Status/tidiness'; and psychological location-specific variables related: 'Pro-local sentiments' and 'Keep on living in village or moving'.

Returning to the formulated hypotheses, we conclude that apart from 'Pollution of soil and water', none of the environmental values/attitudes variables were found to be significant explanatory variables for the four action response variables (A–D). None of the psychological variables was explanatory.

Under the situational section, none of the variables under Socio-demographics were significant, but under Socio-economics, 'Social status' was partly confirmed (positive explanatory effect in Model 1, but disappeared in Model 2). Moreover, 'CPC membership' was found to

be a significant explanatory variable generally resulting in more actions. Regarding farming experience/knowledge, both 'Farming competence' and 'Instructions on fertilisers' were confirmed as having a positive explanatory effect on the response variables.

Assessing the role of family income, which is a more ambiguous explanatory variable, it was found that this had a significant negative effect on several of the action variables. This implies that those on low income are taking more actions (Tables 2 and 3).

Discussion

Explanatory factors governing actions

The link between environmental values and environmental actions claimed in the reviews by Chen et al. (2011), Harris (2008a), and Feng and Reisner (2011) is not confirmed in this study of farmers in the Yuqiao watershed, possibly alluding to differences between environmentally sound consumption among city dwellers and actions by farmers, especially pertaining to farmers' opportunities to conduct environmentally sound farming. Generally, it is

Table 2. Stepwise linear regression model for sum of all actions and environmental actions.

	A: All actions					B: Production-oriented actions				
	Model 1	Model 2				Model 1	Model 2			
	Step 3	Step 1	Step 2	Step 3	Step 4	Step 2	Step 1	Step 2	Step 3	Step 4
Gender										
Year of birth										
Own education										
Jobs outside farming										
Family income	−.127*				−.180**					
Social status in village	.139*					.129*				
CPC membership	.139*		.180**	.183***	.204***	.126*				.125*
Village poverty										
Farming competence		.270***	.271***	.260***	.255***		.255***	.239***	.232***	.233***
Knowledge of P										
Contact frequency										
Instruction in use of P				.173**	.197***			.209***	.197***	.197***
Farming: pollution									.163***	.145*
Motives: health/environment										
Locality										
Pro-local mean										
R^2	.054	.073	.105	.135	.167	.036	.065	.108	.135	.150
Durbin–Watson	2.031				1.945	1.914				1.957

Note: Shading in the tables means variables not part of that actual regression model.

Table 3. Stepwise linear regression model for production-related actions and clustered actions.

	C: Environmental actions					D: Clustered actions				
	Model 1	Model 2				Model 1	Model 2			
	Step 2	Step 1	Step 2	Step 3	Step 4	Step 2	Step 1	Step 2	Step 3	Step 4
Gender										
Year of birth										
Own education										
Jobs outside farming										
Family income				−.158**	−.178***					−.138*
Social status village	.138*					.121*				
CPC membership					.165**	.122*		.142*	.140*	.158**
Village poverty										
Farming competence		.196***	.187***	.189***	.187***		.178***	.178***	.166**	.168***
Knowledge of P										
Contact frequency										
Instructions in use of P			.160**	.175***	.174***				.141*	.152*
Farming: pollution										
Motives: health/environment										
Locality										
Pro-local mean										
R^2	.019	.038	.064	.089	.115	.033	.028	.044	.061	.090
Durbin–Watson	1.954				1.965	1.957				1.951

Note: Shading in the tables means variables not part of that actual regression model.

easier for city dwellers to adjust their consumption than for farmers to adjust their farming practices. Consequently, farmers may have strong environmental values but situational factors might function as barriers to taking environmental friendly actions.

Analysing the NEP and DSP world views, Orderud and Vogt (Forthcoming 2015) found, for example, that (partly) gender (women) and farming motives of health and environment were linked to a NEP world view, while (increasing) age and farming motive of status were linked to a DSP world view.[9] In this study none of these variables proved to be explanatory for taking any actions (A–D). This contradicts the findings of Chen et al. (2011), and again, alludes to a different basis for environmental values and taking actions. A reasonable hypothesis might be that the long history of living and practising farming in landscapes fully transformed by human activities (Elvin 2004) is framing farming practices and how farming is practised.

Instead, this study identifies the following factors as explanatory variables for taking more actions: farmers considering themselves to be good farmers; receiving instruction on the use of fertilisers; CPC membership; and (partly) low income. This means that it is first and foremost situational variables through the category of socio-economic variables and (farming) experience that appear to be relevant for understanding the extent of actions taken by farmers.

As argued above, the role of CPC membership may be linked to the political-administrative context of China, with pro-action and -environmental signals from above finding a higher receptivity among party members than others. This, then, confirms the findings of Xiao et al. (2013). However, this might instead be due to grassroots-level 'doers' and community builders to a larger degree aspiring to join the CCP. Moreover, such people, proving themselves through taking actions, more than others are invited and admitted into the CCP at the village level. The role of low income supports the findings of Li (2003).

The significant governing role of (self-reported) good farming competence and receiving instructions on the use of fertilisers is conceptually reasonable: farmers with above-average agricultural knowledge and who seek information are inherently enabled to take more actions than others. Over time it is also reasonable that those taking more actions than others consider themselves as having better competence, reinforcing both self-image and taking of actions.

However, it is important to realise that willingness to take actions is not the same as possessing adequate environmental knowledge, or environmental literacy, to conduct good agriculture management practice actions, as indicated by the lack of any statistical significance of variables in the analysis representing environmental knowledge. Having received instructions on the use of fertilisers does therefore not mean that one has the understanding of the effects of over-fertilisation as the cause for eutrophication leading to deterioration of water quality. In fact, farmers in the study area seemed to think that the application of P in the fields has no negative effects. The capacity of the soil in the studied watershed to retain P is very poor, mainly due to low organic content and a predominance of clay minerals with poor sorption capacity (i.e. 1:1 type) (Pettersen 2014). This condition, coupled with extreme over-application of P, has led to the uncommon situation in which it is the highly bio-available inorganic orthophosphate that is the main P fraction in the channels and rivers draining into the reservoir, rather than particle-bound P (Ojwando 2014). A confounding issue is that in order to maintain good harvest on these poor soils, farmers need repeatedly to add fresh bio-available and mobile orthophosphate during the growing season.

Comparative study between Norway and China

Among Norwegian farmers, 'the more P, the better' is conventional wisdom, together with a belief that autumn ploughing is required to ensure a good harvest the following year. These were practices that were considered essential to change in order to significantly reduce leaching of nutrients to water streams and eventually to curb and abate eutrophication of water resources, as was the case of Lake Vansjø in the Morsa watershed. Achieving these changes was not plain sailing, and especially not so in regard to fertiliser-intensive vegetable production. As concluded by Orderud and Vogt (2013) and Barton et al. (2015), the implementation of *reducing* the use of P has been a success in Norway, whereas reduced or no autumn ploughing remains controversial. Applying less fertiliser and mineral fertilisers with lower P content was achieved by cooperating with highly respected local farmers (role models) and receiving support from the Agriculture Advisory and Experimental Society.[10] These farmer role models managed to prove to their fellow farmers that one could reduce the application of P without compromising production yield. However, this was not the case for autumn ploughing: many farmers were unable to achieve the same output after introducing reduced or no autumn tillage, and thus were reluctant to take such actions, alluding to the claim of Burton and Wilson (2006) in regard to the presence of a production-oriented identity among farmers. A consideration of the vast differences between the two cases of China and Norway clearly illustrates how context demands differing abatement measures. However, a similar approach might be applied for introducing and implementing the amended measures: convincing respected local farmers to act as pioneers subsequently advocating a major reduction in the amount of P applied might also work in the Chinese context. Nevertheless, the poor P sorption capacity of the soils in this study area makes the case of Yuqiao more difficult, demanding measures other than those proving successful in the Norwegian case. Moreover, controlling the loading of P to the reservoir is more difficult due to a lack of receptors for superfluous sewage and manure. Returning to the

meticulous and laborious reuse of organic waste by adding it to the soil, as done in China well into the twentieth century (King 1927; Fei 1939, Crook and Crook 1966), might not be a feasible option and may not contribute to solving the problem.

Implications pertaining to agricultural and environmental policies

Increasing prices of agricultural commodities in the market is not the most important action (Action 6; Table 1). On the contrary, production-oriented actions of increasing output as well as improving the quality are more prominent explanatory actions. Moreover, the multivariate analysis revealed that those with a low family income were taking more actions than those with a high income. In this context, it is important to underline the fact that tailoring fertilisation advice to individual farmers based on physiochemical soil data, as conducted in Western countries, is not practicable in the study area (and many other places as well) because of the dominance of small-scale farming. This requires instead the provision of general recommendations based on regionalised sampling. Nevertheless, it is clear that ongoing massive over-fertilisation (e.g. Sanders 2006; Yuan et al. 2011) implies that farmers can reduce the application of fertiliser without experiencing reduction in agricultural yield, which is also underlined in other studies. The poor ability of the soil to adsorb P augments this negative effect by allowing most of the phosphate to leach out of the soil, as well as by generating the need to apply fertilisers several times during the growing season. Moreover, it is known that good environmental knowledge, supported by pro-environmental values and attitudes, facilitates adherence to environmentally sound farming practices.

Contrary to Shi and Gill (2005, p. 226), who claim that 'farmers will not be persuaded to engage in ecologically sound activities that are not economically beneficial', we argue that there is scope for actions without necessarily providing economic gains, as long as economic losses are avoided. We contend that 'stick-and-carrot' economic incentives are vulnerable to budgetary changes. Extending the pro-environmental values and attitudes to also incorporate caring for the 'downstream environment', vital in terms of the eutrophication issue, requires an attitude of caring for the 'other', meaning other humans as well as other species/ecosystems; if not in the manner of a cosmopolitan balancing of market forces through a 'global ethos' and tolerance for otherness (e.g. Beck 2006), at least in the manner of reciprocal solidarity among communities at the local and regional scale. The support for the NEP world view and the role of CPC membership documented above indicate a fertile basis for such solidarity.

It is important to underline that facilitating solidarity does not mean discarding the economic factor. Farmers are part and parcel of the current socialist market economic system, and introducing measures incurring significant economic losses will naturally undermine farmers' willingness and in many cases their opportunity to take actions – especially in times of general promises of economic growth, higher income, and improved welfare.

Bearing these economics in mind, a first measure would be to organise the appropriate handling of dung and sewage. Currently, the small-scale biogas reactors for families that are in use are simply adding to the eutrophication problem by converting organic P compounds to more labile inorganic orthophosphate. Biogas reactors were introduced in China in the late 1950s by importing the technology from the Soviet Union and the German Democratic Republic: 'following anaerobic fermentation, the residual material (biomass) was applied to the fields and pastures as high quality fertilizer' (Wagner 1987, p. 137). The somewhat down-scaled Chinese models failed due to poor availability of reinforced concrete, but in the late 1960s a small-scale reactor for individual farming households was introduced. The time might be ripe for returning to large-scale biogas reactors run by townships or counties, or as farmers' cooperatives, thereby relieving the local surface waters of much bioavailable P (sewage and manure). Such an initiative will potentially find a receptive audience in villages, as indicated by a relatively high score for action 11 in Table 1. As the multivariate regression analysis indicates, the grassroots of the CPC in particular might engage in tasks of this kind. Moreover, this would build on and enhance a grassroots recycling farming culture to a higher geographical scale, but it is also important to note that economic support might be necessary for bringing such reactors into operation.

Orderud and Vogt (Forthcoming 2015) suggested combining the facilitation of pro-environmental values and attitudes with learning and knowledge. Although the above analysis does not confirm any link between the NEP world view and actions, it is still the case that learning and enhancing the knowledge, and literacy, about sound environmental farming is important. We have indicated in this study that farmers generally have rather small parcels of land for farming, and although some are leasing land from others, a policy for increasing the parcel number per farmer will most likely be a result of the general policy pursuing the modernisation of agriculture. Then, it will also be necessary for farmers to improve their farming competence, through formalised education as well as more practical training. Consequently, a comprehensive national policy for developing a system for learning about agronomical-environmental farming practices should be introduced, thereby also helping China become capable of accommodating the policy of increasing urbanisation from around 50% to 70% by 2030.

Returning to the Norwegian case, the promoted measures were based locally on municipal mayors being members of the Watershed Board, thereby facilitating their commitment to implementing actions agreed upon by the Board: actions that also included directives from higher political and administrative levels. In short, this process has been an interaction between local initiatives (model

farmers) and directives from above (Naustdalslid 2015). Conventional understanding of the Chinese political-administrative system is one of authoritarian top-down governance. However, recent studies have modified this picture by pointing at interactions between different levels, alternatively termed fragmented authoritarianism (Lieberthal & Oksenberg 1988); adaptive governance (Heilmann & Perry 2011); policy learning, or experimentation under hierarchy (Shi 2012); the bifurcated governing strategy of deregulation and re-regulation according to sectors' strategic importance (Hsueh 2011); or project governance (Qu 2012). The Chinese tradition of experimentation locally and subsequent top-down directives might, in combination with the role played by local CPC members, provide a basis for a similar process as that applied in the Norwegian case. Local participation could be enhanced by establishing village cooperatives organising the collection of sewage and manure, as well as a sound usage of fertilisers, thereby countering the presence of small plots of land among farmers. Gradually, those most active in farming might be allocated larger parcels of land, making farming more effective and allowing for tailored fertilisation advice.

Admittedly, the above policy recommendation has a North European ethnocentric perspective by suggesting measures allowing and establishing a basis for local farmers and villagers to continue living and practising farming in the area. China has a tradition of deporting people from their homes and their land when considered necessary, with the issue being to find adequate (economic) compensation. Removing most or many of the 130,000 residents in the Yuqiao area, thereby efficiently reducing emissions of sewage, is of course possible. This might be combined with redevelopment of the area by, for example, introducing large-scale, industrialised farming; opening the clay-rich fluvial delta for industrial exploitation; upmarket leisure resorts; or facilitating gentrification by urbanites working in Beijing and Tianjin, as described by Qian et al. (2013) for the Guangzhou region in Guangdong Province. Possibly the total leaching of nutrients might be kept at levels not causing any serious algal blooms or inferior water quality, but each of these redevelopments will most likely have their own negative consequences.

Notwithstanding differences between China and Northern Europe, the survey conducted in the Yuqiao area included questions showing that half of the respondents wanted to continue living in their village; about a quarter expressed a desire to move, and the remainder were unsure what to do. In addition, a majority also awarded the social milieu very high scores on a 6-point Likert scale (between 60 and 70%) – for example, 'people helping each other when needed' and a 'good place for children to grow up'.[11] These results provide some justification for the approach chosen in the project and presented in this paper, demonstrating that it is possible to come to grips with the eutrophication problem in Yuqiao without the need to take any radical societal measures such as large-scale removal of residents.

Conclusions

From the above analysis and discussion, we reached the following conclusions.

Taking agro-environmental actions was not governed by pro-environmental values. Rather, the extent to which farmers conducted actions was explained by situational variables (Barr 2008) such as whether or not they considered themselves as good farmers (and having high social status); were literate regarding the use of fertilisers; were CPC members; or had a low family income.

The absence of links between values/attitudes and actions, as well as the absence of links between the young and females and actions, indicate a different set of governing mechanisms among rural compared with urban dwellers.

Poor capacity of the soil to sorb nutrients results in farmers applying excessive amounts of fertiliser several times during the growing season. Lack of sound means of disposal of household sewage and dung from husbandry results in it being deposited on wasteland or directly into drainage channels. A shallow plough layer and poor percolation capacity of the soils leads to rapid sub-lateral and overland flow during times of heavy rainfall. This flushes out excess fertiliser, along with large volumes of manure and human sewage.

Although different contexts (physical and institutional conditions) between China and Norway prohibit any direct transfer of policies and measures, the role of protagonist farmers in regard to changing of practices, such as the over-use of fertilisers, might also be useful in China. How role models are used might differ, though.

A policy of learning and developing sound farming practices, combining agronomical and environmental principles, should be formulated and implemented, thereby preparing China for a modernised and sustainable agricultural system.

A policy of gradually increasing the parcels of land for each farmer should be pursued, thereby allowing for more tailored advice regarding application of fertilisers.

A system for collection of excess manure and human sewage is required, bringing it instead into reuse by developing large-scale biogas reactors. This needs to be combined with returning organic matter to the soil, thereby in the long term increasing the soil's retention capacity.

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Notes

1. On the other hand, Wong et al. (2015, p. 109) define ecosystem services as the 'indirect contributions of ecosystems to human well-being', and final ecosystem services as 'components of nature possessing an explicit connection to human well-being that have direct value to society' – a truly anthropocentric perspective that would not fit easily within an ecological economics perspective. Moreover, the focus on marginal changes in service production and economic values indicates an economistic perspective.
2. This seems very much like a sort of local game of 'who blinks first', with local farmers acknowledging the need to set aside land for the good of the local habitat of pandas, and the question is, 'who will make the offer?'
3. SinoTropia; RCN no.: 209,687 and CAS.
4. The selection of villages was made with the assistance of a local village leader with good local knowledge. In each village, the survey was announced by word of mouth and loudspeakers. Residents showed up at will and the questionnaires were filled in on the spot.
5. In regard to age: 30 and below: 21.5%; 31–40: 17.7%; 41–50: 24.5%; 51–60: 22.2%; 60 and above: 14.1%. A representative sample would have demanded a top-down approach, with government officials being in charge of the survey. In order to allow the guiding of respondents, we opted for the bottom-up strategy of cooperating with village leaders.
6. Linear regression was chosen after checking the linearity by normal P-P plot charts, which showed the curves of Model A–D described below to as close to the linear axis.
7. A new push for industrialisation, information technology application, urbanisation, and agricultural modernisation (South China Morning Post 2012).
8. The NEP scale is based on 15 statements, of which compliance with eight represents a NEP world view and compliance with the seven others represents a DSP world view.
9. The study by Orderud and Vogt (Forthcoming 2015) was conducted on exactly the same sample as was used in the analysis presented above.
10. The Agriculture Advisory and Experimental Society simply spreads practical learning among farmers with the help of professionals, with regular local meetings for and among farmers.
11. As expected, multivariate regression analyses show that the young are somewhat more prone to want to move and that their elders are more positive regarding the social milieu, but this does not mean that the young generally support statements like 'gossip everywhere' and 'boring life here'.

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Annex 1. Definition of variables.

Variable	Values	Type
Gender	1: Females (72.0%); 2: males (28.0%) (N = 496)	Nominal
Year of birth	Years; 1951–1952–1953, et cetera	Numerical
Own education	1: No formal (7.3%); 2: Primary (18.9%); 3: Secondary (47.6%); 4: High school (20.3%); 5: College/university (5.9%) (N = 454)	Ordinal
Jobs outside farming	1: Only farming (33.8%); 2: farming and want to work outside (26.9%); 3: Working outside farming (39.3%) (N = 494)	Ordinal
Family income	Total income for all family members	Numerical
Social status village	1: Bottom (17.3%); 2: Middle-low (18.0%); 3: Middle-high (20.0%); 4: Close to top (16.4%); 5: Top (28.3%) (N = 434)	Ordinal
CPC membership	1: None (74.4%); 2: One or both parents (19.9%); 3: Husband or wife (3.9%); 4: husband or wife plus one/both parents (1.0%); 5; Husband/wife plus one/both parents (0.8%) (N = 508)	Ordinal
Village poverty rate	Percentage of respondent's family in each village below 60% of median family income	Numerical
Variable – short	**Definition of variable**	**Type**
Farming competence	Response to 'How do you consider your competence in farming?' Six-point Likert scale.	Ordinal
Knowledge of P	Average score on 13 statements about positive effects of the use of phosphorus, of which 7 are false. False statements scores are inverted. Six-point Likert scale.	Numerical
Contact frequency	Average score for contact frequency with seven actor categories (farmers, village committee, supplier firms, etc.). 1 = weekly; 2 = monthly; 3 = 1–2 times/3months; 4 = once half year; 5 = Yearly or less; 6 = never.	Numerical
Instructions on P use	Sum of scores of instructions for when to use, how often use, and how much sewage, manure, and mineral fertiliser to use (yes = 1, no = 0).	Numerical
Farming: pollution	Average score on pollution related features of farming (soil and water). Six-point Likert scale.	Numerical
Farming: tidiness/status	Average score on tidiness and status of farmers as features of farming. Six-point Likert scale	Numerical
Motives: health/environment	Average score on health and environment as motives for farming. Six-point Likert scale.	
Locality	How long the respondent wants to live in the village. 1 = stay rest of life; 2 = move as soon as possible; 3 = move within 5 years; 4 = move between 5 and 10 years; 5: move after 10 years; 6 = do not know.	Ordinal
Pro-local mean	Average score on statements 'good and stable social relations' and 'asset that everyone helps each other when needed'. Six-point Likert scale	Numerical