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National Academy of Agricultural Science (NAAS) Rating : 3.03

Study of Acceptance of Human Urine by Indian Farmers as a Soil Conditioner and Water Source

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ABSTRACT: The use of waste water in agriculture as a source of fertilizer and water is prevalent among Indian farmers for some time now. Similarly, new research and field application of liquid fraction of anthropogenic human waste - human urine - has for some time now been recognized as a potential nutrient source. Leaving few research reports on human urine application in agriculture, there is less information available about the farmers' acceptability for human urine as soil conditioner and water source. This research paper brings in comprehensive survey among farmer community across India about the perception of Human urine use in agriculture.

Key words: Human Urine, Soil conditioner, NPK, Farmer survey.

INTRODUCTION

It is estimated that in India about 1,00,000 tons of human excrement is left each day in fields of potatoes, carrots and spinach, on banks that line rivers and along roads (Coffey *et al.*, 2014 [4]). This fecal load generated every day is largely due to open defecation and the absence of facilities for safe and sanitary disposal of excreta. Open drains and disposal of solid waste near sources of water lead to the presence of ammonia in drinking water sources. Defecation on the boundaries of water bodies results in bacteriological contamination of water.

Farms near cities often supply relatively inexpensive food to households in these cities (Bhamoriya, 2004 [2]). Most of these operations draw irrigation water from local water sources. Facing water shortages and escalating fertilizer costs, farmers in many developing countries end up using raw sewage to irrigate and fertilize their cropland and India is no exception. When sewage sludge is used, the use of expensive chemical fertilizer can be avoided as the sludge contains the same critical nutrients i.e. nitrogen, phosphorous, and potassium (NPK) (Strauss and Blumenthal, 1990 [25]). Unfortunately, when this sludge is used for agricultural irrigation, farmers risk absorbing disease-causing bacteria and so do consumers who eat the produce raw and unwashed. This poses huge problems when farmers try to market, in particular export, these crops as they fail stringent contamination standards in the developed markets.

Many environmental scientists, however, argue that the social and economic benefits of using untreated human waste to grow food outweigh the health risks (Minhas and Samra, (2004) [16]; Sengupta, (2008) [24]). Irrigation is the primary agricultural use of human waste in the developing world but frequently untreated human excreta harvested from latrines is delivered to farms and spread as fertilizer.

With several new and time tested indigenous technologies available for recycling waste water and for treating human waste, the attractiveness of using this highly available low cost alternative can be suitably refined and enhanced. Though such pertinent and effective technologies are available, little has been done to educate farmers on the benefits of such solutions. While civil society organizations, under the aegis of several government schemes, have built sanitation facilities in villages, they have often

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remained unutilized. The reasons for this could be myriad- from cultural practices to fear of drinking contaminated water - but an overarching fact remains that many of these measures have been thrust on the rural residents without their active buy in, ownership or their understanding of the advantages that these could bring (Coffey *et al*., 2014 [4]).

The fact that the by-products of such solutions have commercial value has either not been adequately explained to the famer or its deployment, exploitation and commercialization has been beyond the reach of individual famers. Simple measures like source separation and composting can be beneficial not only for the environment but in themselves can earn returns for the farmers. Most of the necessary plant nutrients are found in human urine. Based on data from five countries (China, Haiti, India, South Africa and Uganda) it has been estimated that on average each person produces about 5 kg of elemental NPK in excreta per year i.e. about 4 kg in the urine and 1 kg in the faeces.

Urine is therefore worth using as fertilizer, especially as its content of NPK is readily available to the plants. The concentrations of heavy metals in human urine are negligible, an important advantage over chemical fertilizer (Palmquist *et al*., 2003 [20]). Urine can be applied in a variety of ways including in undiluted form to soil beds before planting where the bacteria in the soil change the urea into nitrate which can be used by the plants, during the entire cropping cycle as a liquid plant food and as an 'activator' for compost heaps where the transformed organic nitrogen will be available to plants when the compost has matured. Concentrated fermented urine can also be applied to beds of dried leaf mold, as a medium for growing vegetables and ornamental plants. A future possibility, when large amounts of diverted urine are available from urban areas, is to use human urine to produce a concentrated fertilizer in powder form.

While the health and ecological benefits of such technologies in terms of cleaner irrigation sources, using the collected urine as fertilizer, the sale of composted waste matter (farm, animal and human) as soil conditioners and using the associated bio gas for cooking-gas or generating electricity is evident to the research communities, like in other parts of the developing world lack of awareness coupled with strong religio-cultural barriers keep farmers from adopting these techniques (Edmund, 2003 [9]). A need was, therefore, perceived to gauge the acceptance levels in framer with regard to the use of human urine for the purposes of irrigation and soil conditioning.

THE AGRICULTURAL CONTEXT

Today, India ranks second worldwide in farm output (UN Report 2011 [26]). Agriculture and allied sectors such as forestry and fisheries account for 16.6% of the GDP in 2009, about 50% of the total workforce. While the economic contribution of agriculture to India's GDP is steadily declining, (13.9%for 2013-14) with the country's broad-based economic growth, agriculture still is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric of India (Annual Report 2013-14[26]).

India has shown a steady average nationwide annual increase in the kilograms produced per hectare for various agricultural items, over the last 60 years. These gains have come mainly from India's Green Revolution, improving road and power generation infrastructure, knowledge of gains and reforms. Despite these accomplishments, agriculture in India has the potential for major improvements in productivity and total output, because crop yields in India are still just 30% to 60% of the best sustainable crop yields achievable in the farms of developed as well as other developing countries (UN Report 2011 [26]).

Planning Commission has demarcated the geographical area of India into 15 agro-climatic regions. These are further divided into more homogenous 72 sub-zones (Fig 1.1). In India, 64% of cultivated land is

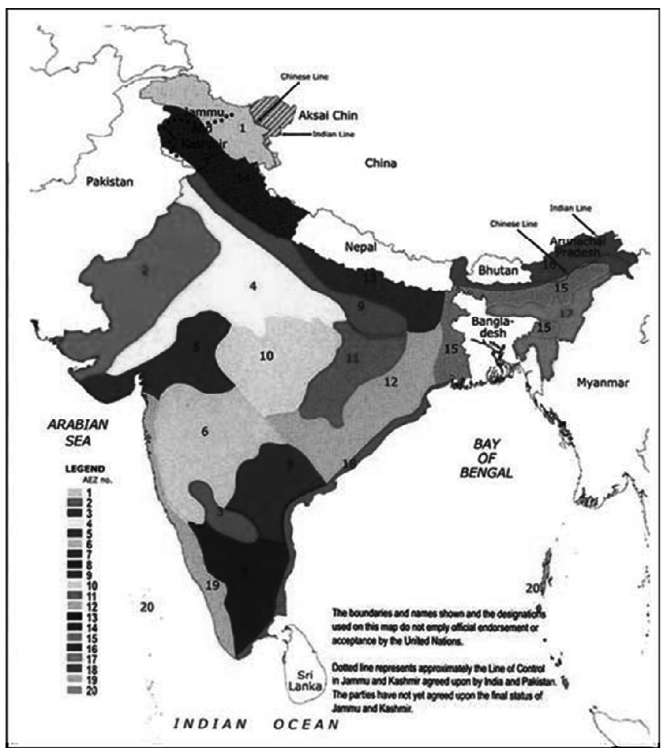


Figure 1.1 Map of Argo- Climatics Zones in India (Rai *et al.*, 2008 [23])

dependent on monsoons. Irrigation in India refers to the supply of water from Indian rivers, tanks, wells, canals and other artificial projects for the purpose of cultivation and agricultural activities. The economic significance of irrigation in India is namely, to reduce over dependence on monsoons, advanced agricultural productivity, bringing more land under cultivation, reducing instability in output levels, creation of job opportunities, electricity and transport facilities, control of floods and prevention of droughts. In 2008 the World Bank's "India Country Overview 2008" report said:

> "*Slow agricultural growth is a concern for policymakers as some two-thirds of India's people depend on rural employment for a living.* ***Current agricultural practices are neither economically nor environmentally sustainable and India's yields for many agricultural commodities are low. Poorly maintained irrigation systems and almost universal lack of good extension services are among the factors responsible****. Farmers' access to markets is hampered by poor roads, rudimentary market infrastructure, and excessive regulation*."

The World Bank also commented that the allocation of water is inefficient, unsustainable and inequitable and that the irrigation infrastructure in the country was deteriorating. The overuse of water is currently being covered by over pumping aquifers, but as these are falling by a foot of groundwater each year, this is a limited resource.

The extensive use of chemical fertilizers also poses a serious threat to water sources in India. According to FAO data up to 2009, China, India and Europe already consume about 60% of the global use of phosphate fertilizer. China is the largest consumer of phosphorus fertilisers in the world with 34% of world total and India is second with 19% of global consumption (FAOSTAT 2012 [11]). Between 2002 and 2009, global use of phosphate fertilisers increased by 12%. India showed the largest increase in phosphate use, almost doubling in quantity between 2002 and 2009 (80% increase).

Generally, phosphate mining is a low efficiency process. For example, in China, only about 40% of the phosphorus mined in the rock phosphate ends up being used as phosphorus fertilisers, the 60% of remaining material is stockpiled or dumped (Zhang et al., 2008 [27]). The million tonnes of mine waste resulting from phosphate rock mining and processing contain significant levels of contamination (from radioactivity to heavy metals). Phosphate rock contains radionuclides of uranium and thorium, and the surroundings of phosphate mines often show increase radioactivity from various chemical elements (Cordell *et al*., 2009 [5]). If crushed phosphate rock is applied to agricultural soils, there is a risk of over-exposure to farmers. It is also important to point out that it is not yet known what long term consequences might stem from the release of these small amounts of natural radioactivity (Righi *et al*., 2005 [22]).

Significant levels of uranium have been found in the groundwater in the intensively farmed state of Punjab in India (Mehra *et al*., 2007 [17]). A recently published newspaper article claimed that the Indian Bhabha Atomic Research Centre (BARC) reported that the use of phosphate fertilisers might be behind the high uranium found in the groundwater. Another concern with the use of phosphate fertilizers derived from mined phosphate rock is the quantity of the heavy metal cadmium. Cadmium is highly toxic to humans. The transfer of small quantities of heavy metals to soils via phosphate rock fertilisers was first identified in 1973 and was confirmed by analysis of archived soil samples at Rothamsted Agricultural Research Institute (UK). Analysis of the samples confirmed that long-term phosphate fertiliser application was a major source of cadmium in soil (Nziguheba and Smolders, 2008 [18]). Application of phosphate fertilisers could, over time, cause cadmium to accumulate in soil and this increases the risk of uptake by crops and transfer through the food chain (Chen *et al*., 2007 [8]).

Phosphate rock is the source of the cadmium in fertilisers and the final concentration of cadmium in fertilisers is not very different from the rock itself. In China, in spite of cadmium content in rock phosphate being relatively low, it was been estimated that the cost of reducing this cadmium contamination would reduce gross profits of the entire phosphorus fertilizer industry in about 50% (Zhang *et al*., 2008[27]). According to Pan *et al*., (2010) [21], the use of these fertilisers "represents a direct input of cadmium to arable soils and subsequently to the environment as well."

A recent study in China has shown that high intensity use of phosphate fertilisers in the Yangtze-Huaihe region of China has led to elevated levels of cadmium in pond sediments of the watershed (Zhang and Shan 2008 [27]). The cadmium levels and their chemical form implied there was a moderately high ecological risk. This was clearly due to extensive use of fertilisers in the region which now "threatens water quality of the watershed and downstream water bodies". Cadmium can accumulate in crops "leading to concentrations in the edible portions of the crop that may be harmful for human health" (Zhang and Shan 2008 [27]). In Sri Lanka, research has been undertaken to assess cadmium levels in agricultural soils and drinking water in the River Mahaweli catchment area after a significantly higher level of chronic renal failure was found in people (mostly rice farmers) in the region. It was found that long-term use of a phosphate fertiliser has contributed to excessive levels of cadmium in the River Mahaweli. The sediments from the river release cadmium into reservoir waters and consequently there is a high level of cadmium in irrigation water and in drinking water that exceeds acceptable levels given by the US EPA (Bandara *et al*., 2011 [1]).

Another chemical element associated with phosphate rock is fluoride. In China, for example, phosphate rock contains relatively high levels of fluoride, and soils and air around phosphate mines showed some enrichment with it (Zhang *et al*., 2008 [27]). Fluoride has beneficial effects on teeth at low concentrations in drinking water, but excessive exposure to fluoride in drinking water and/or from other sources, can adversely affect human health (WHO, 2006 [10]). Effects range from mild dental fluorosis to crippling skeletal fluorosis, a significant cause of morbidity in a number of regions of the world. Increased levels of fluoride in drinking water wells have been associated to high use of phosphate fertilisers, for example in intensive agriculture areas in West Bengal, India (Kundu and Mandal, 2009a, 2009b [13,14]).

While exact timelines may vary, the fundamental problem of phosphorus scarcity is imminent and consequently the production costs have increased as well. Recent analysis of the flow of phosphorus from “farm to fork” illustrated that an appreciable amount of phosphorus that is “lost” along the way when passing from mine to field to fork (Cordell et al., 2009, 2012 [5, 6]). The losses are significant, and overall major losses in absolute amounts are concentrated in two main subsystems: arable land and livestock production. Arable land losses are due to inefficiencies in farm management: 33% of the phosphorus entering the soil is lost by erosion (both wind and water). Only between 15-30% of the applied phosphorus fertiliser is actually taken up by harvested crops. Losses at the livestock production level are mostly due to improper management of manure, about half of the phosphorus entering the livestock system is lost into the environment instead of reapplied to farm soil where it could be used by subsequent crops. Both sectors (arable and livestock) have also internal low efficiencies in the use of phosphorus (33% and 45% losses, respectively).

Humans are the other subsystem where absolute losses are not very large, but relative capture of phosphorus into the agriculture system is very low (90% is lost). On a worldwide scale, we are mining five times the amount of phosphorus that humans are consuming in food, and only about one tenth of the phosphorus entering the agriculture system is actually consumed by humans. Overall, about 90% of the phosphorus entering the system is lost into the environment. Mitigation strategies would include:

1. Stopping or minimising losses, by increasing efficiency in the use of phosphorus, mostly in arable land and the food chain. Additionally, sustainable phosphorus-use will benefit from shifting to plant-rich diets that are more efficient users of phosphorus (and other resources) than meat-rich diets, and from minimising food waste.
2. Maximising the recovery and reuse of phosphorus, mostly of animal and human excreta, and thus minimise the need for mined phosphorus.

In the last 50 years, the quantity of mineral phosphorus used has tripled worldwide. India was mostly reliant on organic manure as fertilizer until the middle of the 20th century. After the introduction of high yielding crop varieties and the development of irrigation facilities during the 1960s, the consumption of chemical fertilisers increased significantly. A recent study looked at nutrient budgets for India for the first time, using figures from 2000-2001 (Pathak *et al*., 2010[19]). The study found that addition of phosphorus in the form of manure is small in most of the states and inorganic mineral phosphate fertiliser accounted for 78% of the phosphorus inputs. Annual removal of phosphorus through crop uptake was estimated to be 1.27 Mt and there was an overall positive balance of 1.02 Mt phosphorus in agricultural soils of India, so that we can roughly estimate that only 0.25 Mt of phosphorus, or 20% of the phosphorus applied, is recovered in the crop. The majority of states had a positive phosphorus balance (surplus), while a few small states had slightly negative balance, and the state of Madhya Pradesh was the most negative (balance of 0.05 Mt phosphorus). The study predicted, however, that consumption of phosphorus fertiliser will increase in the future and use efficiency will have to improve in order to feed a growing population. It was also suggested that increased use of manures would help and for this, there is a need to “promote a more dynamic manure market". Presently, the manure market in India is unorganized and localized manure price has been higher than chemical fertiliser in terms of nutrients. At the same time, the chemical fertilizer market is state-supported (subsidised prices).

In 2007–2008, the extreme price increases for phosphate mineral fertiliser took the world by surprise. In India, which is totally dependent on phosphate imports, there were farmers' riots and deaths due to the severe national shortage of phosphorus fertilisers. Unfortunately, viable alternatives like human excreta were not considered.

Today, it is estimated that only 10% of human excreta finds its way either intentionally or non-intentionally back to agriculture or aquaculture (Cordell *et al.*, 2009 [5]). Current sanitation systems in industrialised countries treat human excreta as a useless residue, wasting large quantities of clean drinking water and energy in sewage plants to manage it ("flush and forget" systems). At the same time, about half of the people living on the planet, 72% of them in Asia, do have access to sanitation facilities (Mihelcic *et al.*, 2011 [15]). However, historically agriculture has often relied on phosphorus input from human excreta to increase food production. In Chinese and Japanese societies, for example, it was an essential input for the high food production that enabled social development. The increasing appreciation of mineral phosphorus (and also chemical nitrogen) as a limited and expensive input for farming is raising awareness of the potential treats to human excreta as a resource rather than a pollutant. About 11% of phosphorus entering the Earth systems is lost in human urine and excreta (Cordell *et al.*, 2012 [6]). If recovered, it has been estimated that it could supply 22% of the current global demand for phosphorus (Mihelcic *et al.*, 2011 [15]). Two facts make of phosphorus recovery in human excreta a promising outlook: first, inexistent sanitation facilities in the many developing countries is an opportunity for creating real sustainable ones, and second, this is very efficient since up to 90% of the phosphorus (and nitrogen) in urine and faeces could be potentially recovered and used to fertilise agriculture lands.

OBJECTIVE

With 82% of respondents in studies around EcoSan solutions in other developing countries like Indonesia stating that system would be beneficial because it would give them the potential ability to produce fertilizer themselves (Water and Sanitation Program-Social Factors Impacting Use of EcoSan in Rural Indonesia) and looking at the water stress in India, it was proposed that a study be conducted to gauge the levels of acceptance amongst India farmers with regard to the use of human urine as a soil conditioner and source of water. While farmers have traditionally used waste water and animal excreta and are aware of the benefits of the same, using identifiable human waste is still considered unhygienic and is socially, culturally and often religiously unacceptable in India as in several other developing countries. Our aim was to see if the challenges associated with shortages in water and the price of chemical fertilizers have changed these perceptions and mind sets.

The hypothesis of the study was

"Considering waste water and cow excreta are widely used for irrigating and fertilizing farms the acceptance of farmers vis-à-vis using human urine for the same purposes would be high especially in the less productive drier areas"

METHODOLOGY

The methodology involved conducting primary research across the country (Fig. 1.2). The methodology involved the development of a questionnaire based on the objective of the study and the testing of the hypothesis. The questions were primarily divided in three broad sections, namely, awareness, administering human urine in past and in present state, reasons for not using human urine and use of urine in future for agriculture purpose. The questionnaire is given in appendix I.

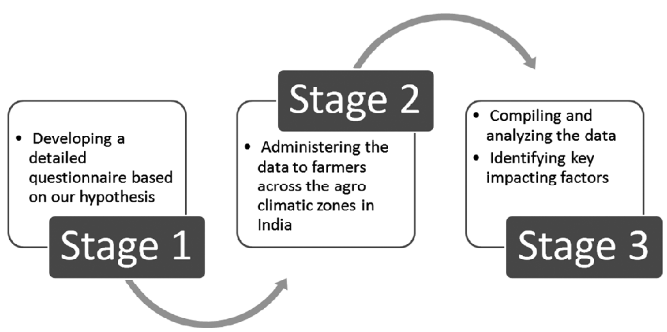


Figure 1.2: Flowchart representation of the methodology followed in the survey

For administrative purposes, the country was divided into six regions which bear relevance to the Planning Commission's agro climatic zone. These regions being:

- Northern Region comprising the states of Delhi, Punjab, J&K, Haryana, Himachal Pradesh, Uttar Pradesh and Uttarakhand

- Western Region comprising the states of Maharashtra, Goa, Rajasthan and Gujarat
- Central Region comprising the states of Madhya Pradesh and Chattisgarh
- Southern Region comprising the states of Andhra Pradesh, Karnataka, Kerala and Tamil Nadu
- Eastern Region comprising the states of Bihar, Jharkhand, West Bengal and Odisha
- North East Region comprising the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura

In each of these regions, one state was chosen based on its representation of the agro climatic profile of the region. The intention was to look at climatic factors, availability or non availability of water, from rain or irrigation, agri productivity and the economic conditions of farmers as determining factors with regard to the use of human urine by farmers. A comprehensive representation of factors like annual rainfall, percentage irrigated land, and major crop production of the zones are stated in Table 1.1.

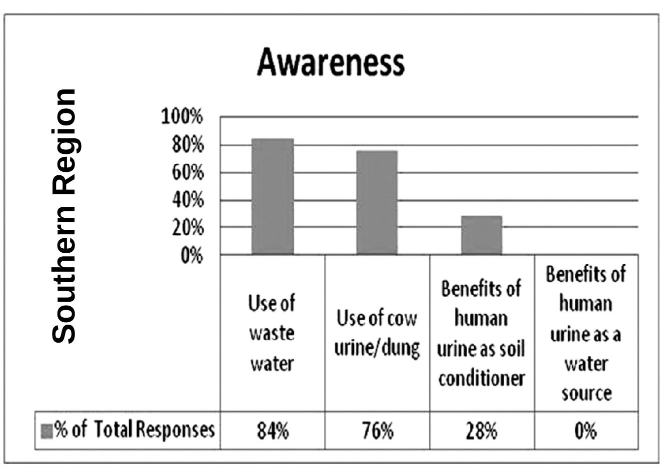
In each state 100 framers were indentified across multiple districts for telephonic / in-person interviews. The farmers were explained the context and thereafter their responses to the questions in the survey questionnaire were sought.

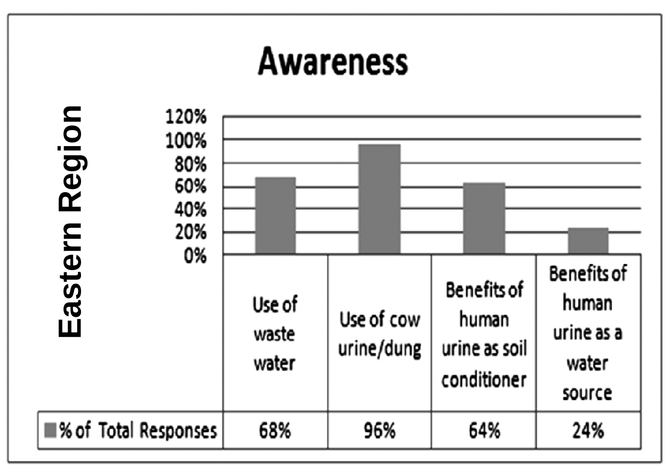
Responses were then compiled, analyzed for regional snap shot and cross-region comparison.

Table 1. 1
Representative data for annual rainfall, percentage irrigated land and crop cultivation in the six agro-climatic zones

Zone	*State*	*District(s)*	*Annual rainfall (mm)*	*% Irrigated land*	*Crop cultivated*
Southern Region	Karnataka	Mandya	700	48	Rice, Ragi, Jowar, Sugarcane, Coconut and Vegetables
		Hassan	1030	20	
		Davanagere	644	38	
		Mysore	782	47	
Eastern Region	Bihar	Muzzafarpur	1280	49	Paddy, Maize, Wheat and Vegetables
		Siwan	1200	57	
North Eastern Region	Manipur	Bishnupur	1400	13	Paddy, Vegetables and Fruits
		Imphal East	1372	19,3	
		Imphal West	1582	Data not available	
Central Region	MadhyaPradesh	Chhindwara	1087	20	Wheat, Maize, Pulses and Peas
Western Region	Rajasthan	Tonk	62	41	Mustard, Wheat, Gram, Masur, Chili and Vegetables
		Dausa	738	73	
		Madhopur	800	60	
		Jaipur	650	46	
		Jhalawar	1020	63	
		Bholwara	634	38	
NorthernRegion	Haryana	Mewat	594	62.8	Wheat, Peas

ANALYSIS AND DISCUSSION





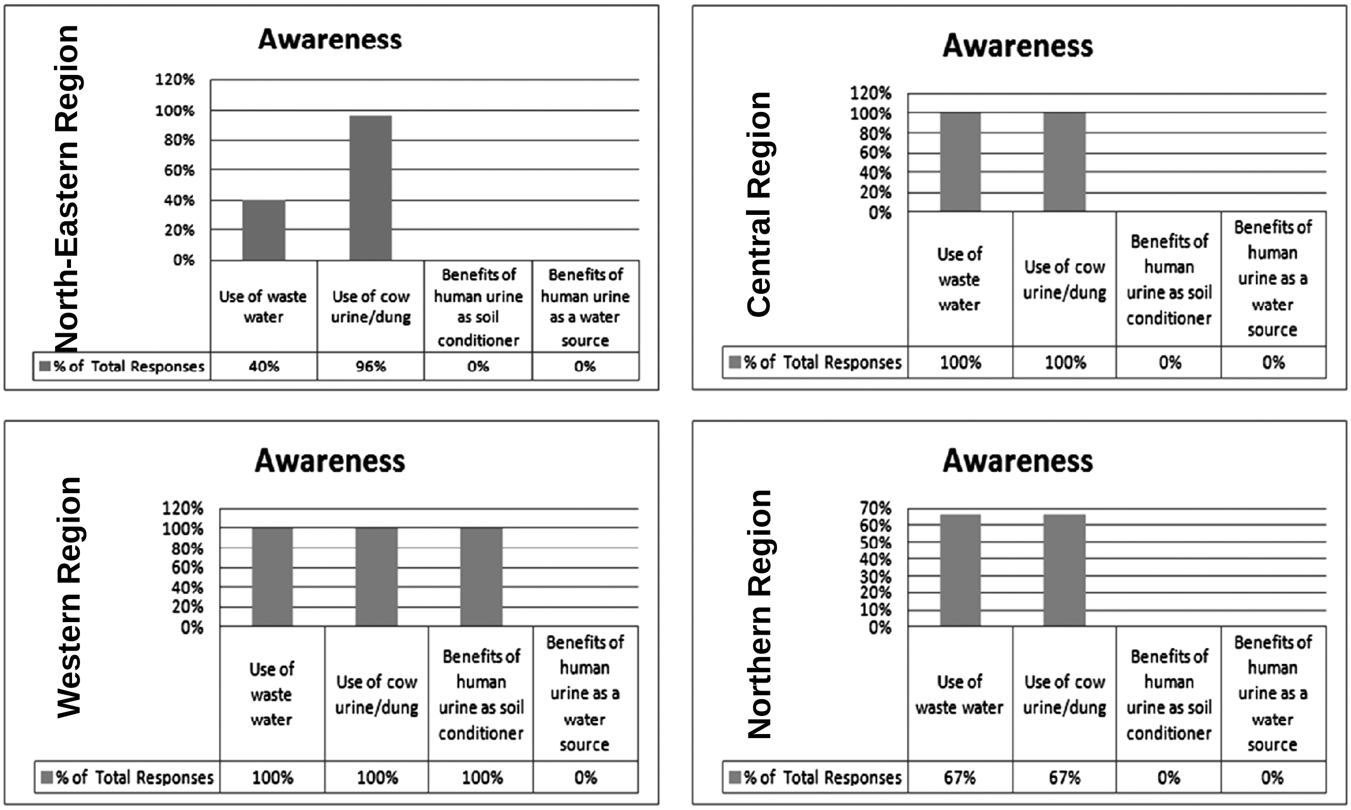
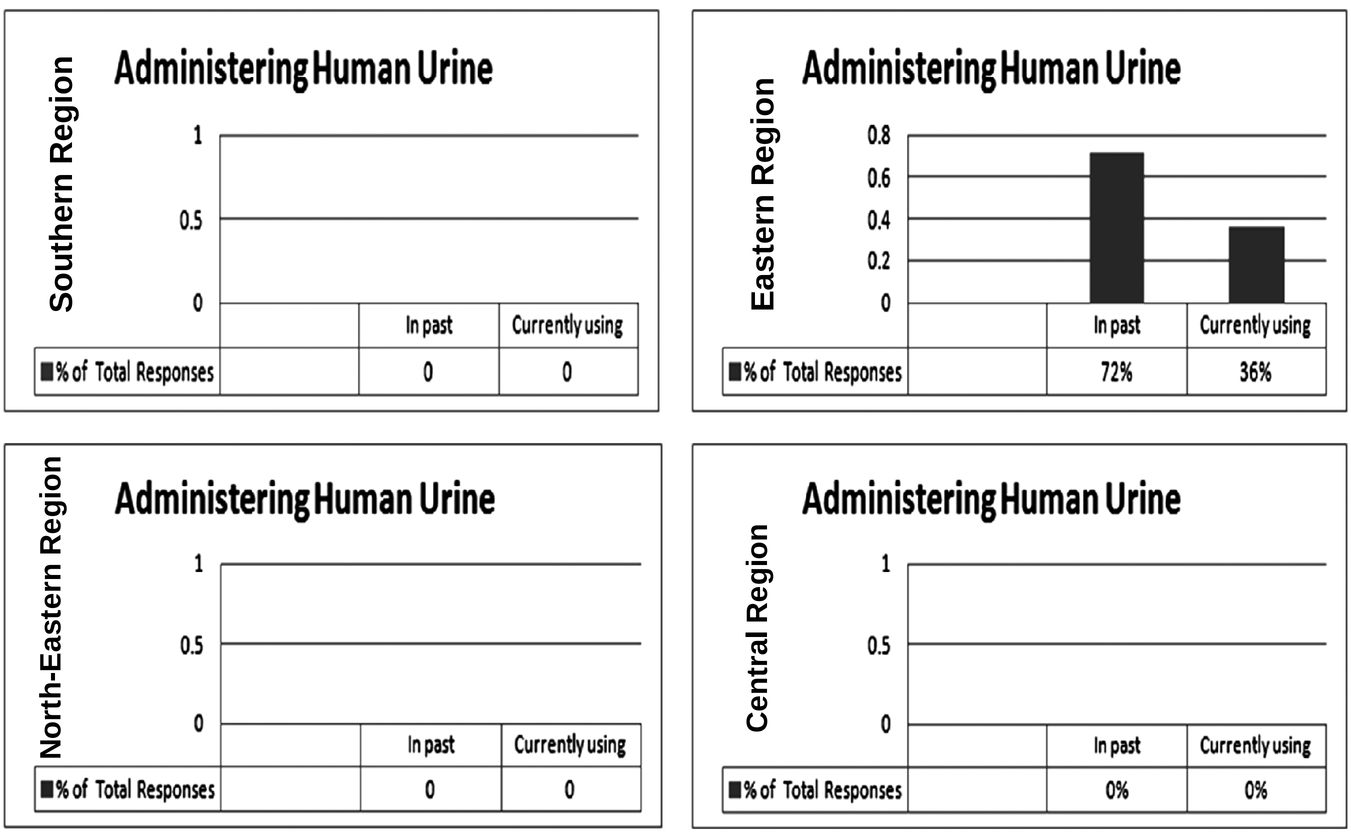


Figure 5.1: Graphical representation of awareness of wastewater and allied components for fertilization of crop in different regions



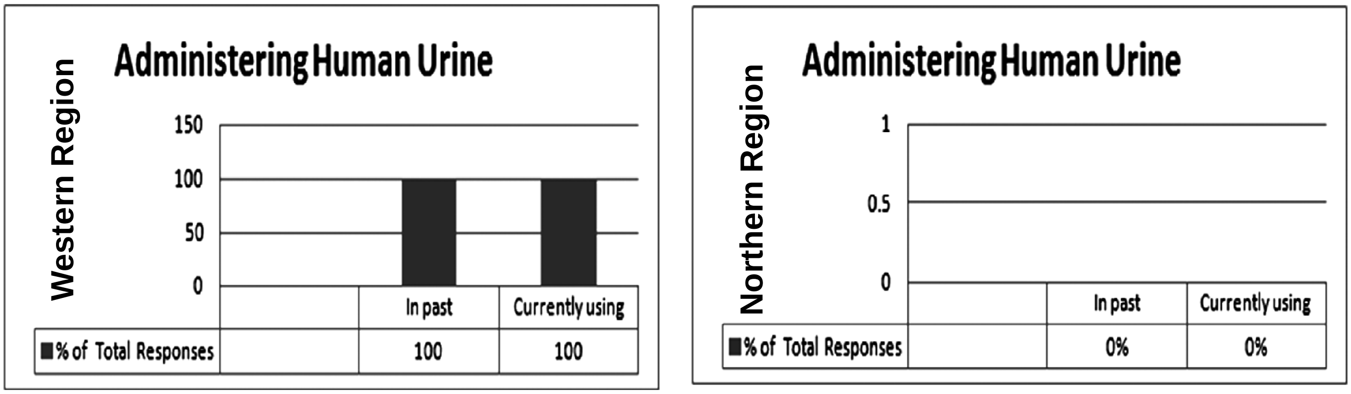


Figure 5.2: Graphical representation of response on administering human urine in the agriculture fields in the six regions

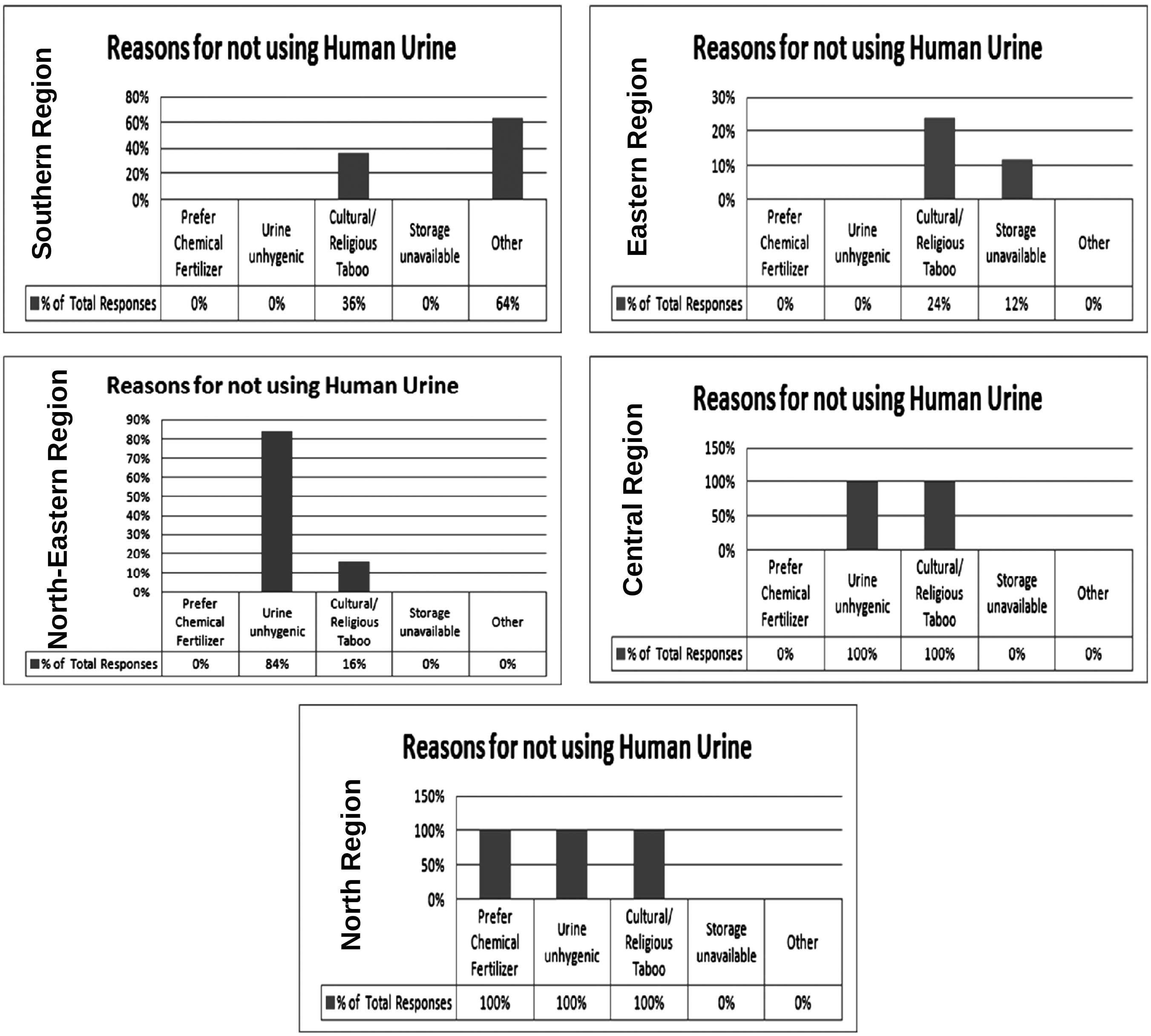


Figure 5.3: Graphical representation of response for reason for not using human urine in respective regions

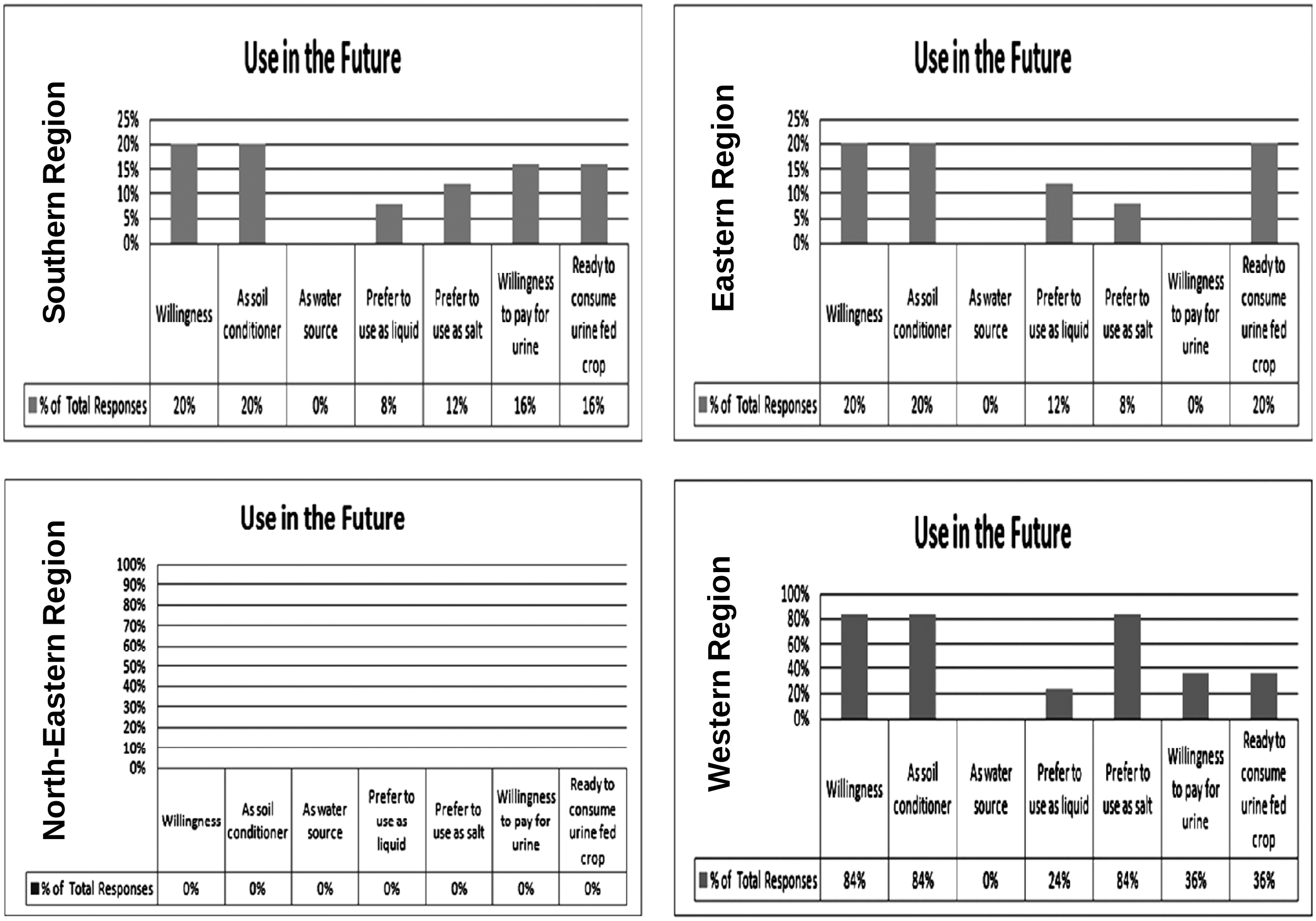


Figure 5.4: Graphical representation of response for using of human urine in agriculture in future

Southern Region

As representative of the Southern Region, the state of Karnataka was chosen. 100 small and marginal farmers were selected from the districts of Mandya, Hassan, Mysore and Davanagere. It is evident that while the farmers are aware of the use of waste water which has a human urine component (84%) and are aware of the use animal excreta (76%). The awareness about urine as soil conditioner is low among the respondents (28%) and they do not have knowledge about using urine as water source (0%). The farmers have so far not administered human urine due to cultural reasons and also more majorly lack of awareness. They indicated that they would not be averse to using this in the future.

When asked about the using urine in future, about 20% of the farmer showed interest in administering it in their fields as a soil conditioner. They also insisted that they would prefer nutrients of urine to be in salt form for easy application. It is interesting to know that 16% of the farmers are willing to pay for the urine for usage and would consume crop grown with urine application.

Eastern Region

As a state representative of the Eastern Region, the state of Bihar was chosen. 100 small and marginal farmers were selected from the districts of Muzzafarpur and Siwan. Poor farmers in this region have used waste water for irrigation and fertigation purpose. The use of cow dung and animal excreta in the field is a widely used practice in this region as 96% responded positive about it. The farmers of the region are well aware of urine usage in agriculture both as soil conditioner and as water source (64% and 24%). They have used human urine for agriculture purpose and are willing to use it in future. The problems cited by the non user are socio-cultural/ religious taboo and unavailability of storage facility for human urine in lager quantity. As the response of the farmers in this region are positive towards the human urine in the region, thus their willingness to use in future and would even like to consume crop fertilized by urine. The farmers are not reluctant to pay for the urine used in agriculture.

North East Region

As representative of this region, the state of Manipur was chosen. 100 small and marginal farmers were selected from the district of Bishnupur, Imphal East and Imphal West. The awareness about the use of waste water and animal excreta in agriculture is well known to the region. But the use of human urine is totally unknown to them. The people considered it unhygienic (84%) and culturally (16%) unacceptable and were totally averse to the use of human urine in their fields.

Central Region

As representative of this region, the state of Madhya Pradesh was chosen 100 farmers small and marginal farmers were selected from the district of Chhindwara. Only 75 of these farmers responded. As in the other regional surveys, the central zone also responded in favour of wastewater use and application of animal excreta on fields. They are unaware of the benefits of human urine in agriculture and have not used it in past. The respondents think that urine in unhygienic and they also have socio-cultural taboo associated to it usage. Though they do not advocate the use of human urine in their fields, but they would be interested to know the benefits of urine in agriculture and if they are assured of its hygienic condition they are willing to use urine as soil conditioner either in liquid of salt form. Yet they were unwilling to pay for it or themselves consume plants grown with urine.

Western Region

As representative of this region, the state of Rajasthan was chosen. 100 small and marginal farmers were selected from the districts of Tonk, Dausa, Madhopur, Jaipur, Jhalawar and Bhilwara. The main crops being grown by the respondent farmers are Mustard, Wheat, Gram, Masur, Chilli and vegetables. The respondents are all aware of not only about the use of wastewater and animal excreta as soil conditioner in their fields but also about the use of human urine as sol conditioner. It is encouraging to know that the farmers have been using human urine in their fields and are more willing to continue to use it. This can be concluded from high number of farmers (84%) voting for urine usage in the agricultural fields. The farmers are more willing to use nutrient salts derived from urine than in liquid form. They are also willing to pay for urine and consume crop grown in urine. When the farmers were asked about the awareness and usage of urine in the fields, it was surprised to know that due to lack of toilets in the region, they openly urinate in fields and thus it has been a normal practice to cultivate on the urinated fields. They also shared that they did not find any difference in the productivity or in the quality of crop cultivated in these lands.

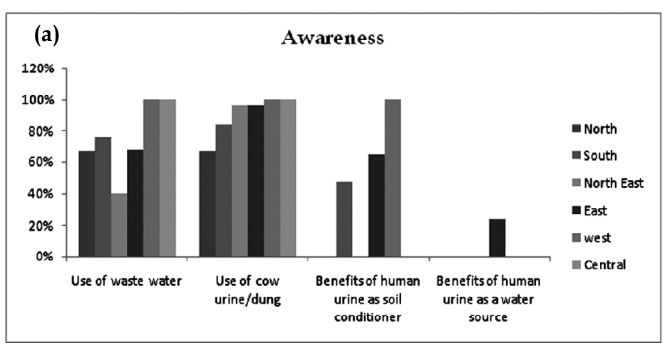
Northern Region

As representative, the state of Haryana was chosen. 100 small and marginal farmers were selected from the district of Mewat. Only 75 of these farmers responded to the survey. The farmers were well aware of the use of wastewater and animal dung for agriculture purpose but did not know about the benefit of human urine in agriculture. As state of Haryana being a high chemical fertilizer consumer the response of the farmers were also similar to the reason for not using human urine. All respondents advocated the use of chemical fertilizers in the fields and thinks it is the only ways of conditioning the lands. Apart from the preference of chemical fertilizers the other reasons quoted for not using human urine are unhygienic condition and socio-cultural taboo related to human urine.

While all 75 respondents initially said they would be unwilling to use human urine they later, when explained to, said that they would like to see a demonstration on its efficacy. If it proves beneficial they would be willing to look at it as a water source. They were willing to try human urine in both liquid and salt forms based on trials/demonstrations in their fields. Yet they were unwilling to pay for it or themselves consume plants grown with urine.

CONCLUSIONS

Comparisons made between the various regions are depicted as below:



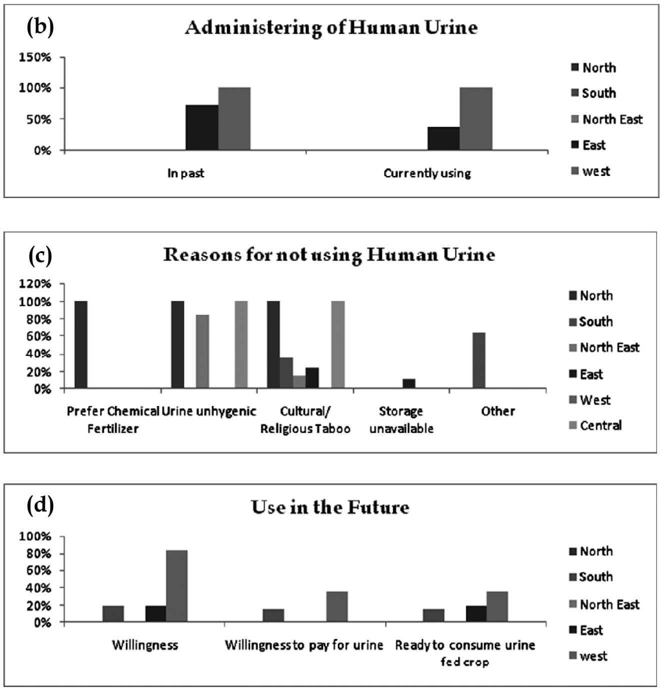


Figure 6.1: Representative data of responses from all the zones

Across all regions a distinct lack of awareness with regard to the benefits of using human urine was perceived. Cultural issues surrounding the use of human urine is the common factor across all regions. Farmers in the western and northern regions were willing to consider human urine as a water source because of a shortage of water in both regions. The lack of willingness to pay for human urine if made available is perceptible – absence of value attached to the urine. As a conclusion it is evident that unlike in other developing countries, human urine still far from acceptable to the Indian farmer as fertilizer or water source. A nationwide awareness building campaign on human urine and its benefits is the imperative.

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ANNEXURE

Acceptance by Indian farmers of Human Urine as a Soil Conditioner and Water Source

Survey Questionnaire

1. Name : Sex : Age :
2. Village / District along with State:
3. Crop(s) cultivated:
4. Are you aware about use of wastewater in agriculture? (Y/N)
5. Are you aware about the use of cow urine and cow dung in agriculture (Y/N)
6. Are you aware of the benefits of using human urine :
   a. as a soil conditioner/fertilizer? (Y/N)
   b. as a source of water? (Y/N)
7. Have you administered human urine in your fields:
   a. in the past? (Y/N)
   b. currently using? (Y/N)
   c. Why did you use the urine?
8. If you have chosen not to use human urine, what was the main reason?
   a. Prefer to use chemical fertilizers ☐
   b. Use of urine is unhygienic ☐
   c. Because of religious or socio-cultural taboo ☐
   d. Non availability of storage infrastructure ☐
   e. Any other reason ____________
9. Would you be willing to use human urine in the future? (Y/N)
10. What would be the main reason for choosing to use the urine?
    a. for soil conditioning/as a fertilizer? (Y/N)
    b. as a source of water? (Y/N)
11. How would you prefer to use the urine?
    a. In liquid form? (Y/N)
    b. As dried salts? (Y/N)
12. Would you be willing to pay for use of human urine? (Y/N)
13. Will you consume crops produced in urine treated land? (Y/N)