UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Drip Tape Use for Annual Crops at the UBC Farm

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ABSTRACT

The UBC farm currently uses two types of technology to irrigate their crops. The problem posed by the farm was to recommend a type of irrigation system for their facility. Two main solutions appeared which could potentially be suitable for use at the farm. Both a drip tape irrigation system and a traditional overhead sprinkler system had pros and cons, and through the use of a triple bottom line assessment an investigation was conducted to see which technology is a more sustainable choice for the farm.

This report covers the environmental, social and economic aspects of each technology. With regards to the environmental impact of each technology the aluminum irrigation was found to be a more environmentally friendly solution for UBC. Although drip tape is perceived to be more environmentally sustainable, there are few places to recycle it in Metro Vancouver, and its lifespan is shorter than the aluminum alternative. Moreover, the aluminum system is made from a readily available resource, which is easily recyclable in many areas throughout Metro Vancouver. With respect to the social impacts, drip tape is regarded to be a better choice. The UBC farm prides itself on raising awareness about sustainability in the community. By having the drip tape technology at their farm the community could be exposed to different irrigation solutions, and it would raise awareness on different types of suitable solutions which are available. When analysing the economic aspect of each technology, the results varied. For larger farms over 20Ha, it appeared that aluminum irrigation the better solution; however, for smaller farms under 20Ha, drip tape is a more profitable enterprise. When considering the small size of the UBC farm it is clear drip tape is the more economically viable solution.

When considering the triple bottom line assessment, it is clear that drip tape is the most suitable solution for the UBC farm irrigation problem. Although it may not be the most environmentally friendly choice, the social awareness it would raise, as well as the economic benefits makes it the better choice.

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1.0 INTRODUCTION

Sustainability has always been the central dogma for the UBC farm and as such it is important to design the farm in such a way to maximize sustainability efforts. Currently the UBC farm uses a dual system of aluminum sprinkler and piping irrigation coupled with a newer technology of polyethylene drip tape. The goal of this paper is to investigate the benefits of the polyethylene drip tape compared to the aluminum sprinkler and piping systems in terms of sustainability. The philosophical and analytical framework of sustainability is built upon analysing the environmental, economical and social factors of a technology, also known as a triple bottom line assessment, and as such this report will follow the same framework to evaluate the two irrigation systems at the UBC farm.

Drip tape as seen by the public is a much more “green” alternative to other types of irrigation systems as it seemingly saves more water with the slower flow rates. However one must ask if this is indeed more “green” in terms of sustainability.

2.0 TECHNICAL DETAILS

Amongst the many other materials for irrigation piping such as PVC, HDPE and PE, aluminum is the most durable and "natural" material of construction for crop irrigation piping. However aluminum irrigation piping systems are rigid and making changes to the piping layout is very difficult. The aluminum piping and sprinkler system sprays water directly over the crops with a radius of spray based on the sprinkler's trajectory angle and operating flow rates, therefore in order to gain a larger radius of water coverage, higher flow rates are required, resulting in greater water consumption.

On the other hand, the drip tape system are less rigid and can be laid across the crop fields much more easily at the cost of extra labour as drip tapes must be extracted from the fields on an annual basis. The general material of construction for drip tape systems are made of polyethylene or similar plastics. The water travels from the source, through pumps into a network of drip tapes with specially designed pores to release a certain amount of water through each tape depending on the water pressure generated through the pumps. One of the major benefits of drip tape systems is the ability to deliver very precise amounts of water to individual crops, unlike the sprinkler system which wastes water by spraying it in between each plant and row of plants.

3.0 ENVIROMENTAL DIMENSION

One of the primary attractions to using the drip tape irrigation system at the UBC farm is to save water. That being said the two systems must be analyzed in a "cradle to cradle" or "cradle to grave" approach, which means the two system must be analyzed from raw material to construction and finally to disposal or recycling. Another important factor that must be analyzed is the long and short term impact of the technologies on the surrounding environment and wildlife.

3.1 ENVIROMENTAL IMPACTS OF DRIP TAPE SYSTEM

One of the main advantages of using the drip tape system is the precise control of water flow delivered to individual crops. In a comparative experiment at the New Mexico State University(6) on irrigation efficiency for onion production sprinkler, trickle (drip tape) and furrow irrigation systems water consumption were analysed. The research showed a 0.084 (t/ha mm) irrigation water use efficiency for the sprinkler system compared to a 0.059 (t/ha mm) irrigation water use efficiency for the drip irrigation system. Although it may not be surprising that the drip irrigation has lower irrigation water use, one must keep in mind that onions requires a very large amount of water and the water evaporation rates in Messila Valley, Southern Mexico (location of the experiment) are extremely high. Therefore the drip tape system must undergo excessive watering to keep the soil wet for onion growth. Other farmers and agricultural researchers reported similar reports for other plants such as tomatoes and alfalfa by the University of California(2)(1). There have also been reports of improved water use efficiency for deep burial of tape (20-40cm deep) and mulching(4), indicating that the main source of water lost is from evaporation.

One major challenge present at the UBC farm is the attraction of wild animals onto the farm by these drip tapes, with coyotes being especially attracted to the drip tape. It has been recorded that they tend to chew on the drip tapes, creating sizeable holes and thus rendering the drip tape useless. The loss of the drip tape is felt financially considering the size of the UBC Farm budget, and how expensive replacing the drip tape is. By burying the drip tapes deep into the ground the coyote problem may be subdued, however not all crops are susceptible to deep burial, and the crop yield may be adversely affected. One concern with the coyotes chewing up the drip tape is the possibility of plastic debris ending up in the animal's diet. Considering the fact that current drip tapes are made of polyethylene, a non-biodegradable plastic, this does not bode well for the coyotes around the UBC Farm.

A production analysis on polyethylene must also be performed to fully grasp the environmental impacts of the drip tapes. Polyethylene is a plastic derived from modifying natural gases such as methane, ethane and propane, or from the catalytic cracking of crude oil. Under the right pressure and temperature in the presence of a catalyst the many monomers of ethylene links to form the polymer polyethylene. Traditional polyethylene (low density polyethylene) requires very high pressure (1000-3000 bar) and high temperatures (300^{o}C) however in the 1952 researchers in Germany and Italy devised an aluminum catalyst that can produce polyethylene under lower pressure (10-80 bar) and lower temperatures (70-300^{o}C) to produce high density polyethylene. Even with the reduced conditions, the production of polyethylene is energy intensive and uses non-renewable source of material, crude oil (and much sought for in modern times).

The end-of-life management of polyethylene drip tape irrigation at the UBC farm as it stands is seemingly quite grim. There are no recycling plants that will accept the polyethylene drip tapes in the Metro Vancouver region, and there is one recycling plant in Richmond that will take these drip tapes for free, given that they are cleaned of dirt and debris. Unfortunately, farmers generally throw out used drip tapes and consequently they end up in the landfill. The tedious job of cleaning the drip tapes before they can be recycled is not seen as a good way to spend time and resources. In understanding the environmental impacts, it is also important to note that polyethylene is not biodegradable and the plastic in landfills will remain as plastic for centuries to come.

In recent years bio-degradable plastic polymers have been developed and implementation of these plastics into the construction of drip tape would make drip tape a greener alternative in farming irrigation.

3.2 ENVIROMENTAL IMPACTS OF ALUMINUM SYSTEMS

Much like the production of polyethylene, aluminum is also a very energy intensive process. The first step in producing aluminum pipings and pieces is the prospecting and mining of bauxite, the primary component in aluminum; bauxite is the hydrated form of aluminum oxide

(Al_2O_3). In almost all cases the mining of aluminum is from open-pit sites, requiring large bulldozers, giant shovels and explosives. One of the most concerning by-products of these operations are tailing ponds which have the potential to severely damage the environment and surrounding communities even with strict environmental regulations. After the extraction of bauxite, the separation of aluminum oxide from the iron oxide must be performed. The bauxite must be mixed with caustic soda and heated under pressure forming sodium aluminate, this is then mixed with aluminum hydroxide to form a material known as alumina (aluminum oxide). Alumina smelting first begins with dissolving alumina in cryolite at 1000^{o}C, and then a process known as electrolysis is used to separate the alumina into pure aluminum and carbon dioxide. The rest of the process into fabricating aluminum pieces is simply casting or extruding.(7)

Although aluminum is a non-renewable resource, it is easily recycled and reused. Amazingly, almost all aluminum products made are still in use today due to recycling.

4.0 SOCIAL DIMENSION

An equally important dimension when talking about sustainability is the social impacts of a technology or idea. In terms of the UBC farm, the stakeholders of such implementation of irrigation systems are the workers at the UBC farm and the neighbouring residents of the farm, as well as any visitors.

4.1 SOCIAL IMPACTS OF DRIP TAPE SYSTEM

The mission of the UBC farm is to be on the forefront of sustainable farming, and as such the implementation of drip tape technology, seen as the most "green" alternative by the public, would be a wise decision. The wide implementation of the drip tape system throughout the farm could act as a showcase of green technology to those who visit, especially in the case of bio-degradable polymers for the construction of the drip tapes.

One of the major challenges to using the drip tape is the necessary labour involved in maintaining the system. The drip tapes must be removed every season and stored for future use. Further, spotting and repairing broken pipe lines with proper connectors is a constant issue with the technology. Extra workers and volunteers would be needed to ensure the system remains in optimum condition, and there would be a need to find storage space and recycling centers for the large quantity of drip tapes that the farm would use.

One of the main advantages of using subsurface drip irrigation is the "hidden from view" aesthetic for visitors and neighbourhood and would create a much more aesthetically pleasing view compared to the traditional metal piping. Furthermore with drip tape recovery machinery the labour required to extract the drip tape can be greatly reduced, creating less stress for the workers.

4.2 SOCIAL IMPACTS OF ALUMINUM IRRIGATION SYSTEM

The main advantage in using a metal piping and sprinkler system is the ease of management. Leaks are easily spotted and are far less frequent than with the drip tape system. Furthermore, with aluminum irrigation proper water management protocols are already established for every type of plant and it is easy to reproduce these results. The metal pipe system would require a lot less labour and with the long life span of the pipes, replacement and storage of equipment is very minimal. Furthermore, no additional training would be required to maintain such a system because it is a well established technology which everyone is familiar with.

5.0 ECONOMICAL DIMENSION

One of the main dimensions traditionally and currently used, and may be a major driving force in deciding different projects, is the cost. Economic viability has always been the forefront in deciding on different solutions to problems and always will be.

5.1 ECONOMICAL IMPACTS OF DRIP TAPE SYSTEM VERSUS SPRINKLER SYSTEM

Researchers at the Kansas State University performed a detailed profitability analysis using the basis of partial budget (indicates whether one enterprise has a net return advantage over the other) on comparing center pivot sprinkler and subsurface irrigation systems for continuous corn, with a wheat-fallow rotation(3). Table 1 below shows capital investment costs for various irrigation arrangements as well as size of these irrigation fields in hectares (please refer to Appendix A for field arrangement drawings). In terms of capital cost, there is an obvious optimum field size where it is in fact less expensive to use the drip irrigation system than the sprinkler system. The trend appears to be that for large fields (approximately 20 hectare or above) sprinkler systems are the better option, whereas for fields of less than 20 hectares the drip tape system is cheaper.

	Center Pivot		SDI	Center Pivot		SDI	
Field Scenario	Irrigated Area	Dryland Corners	Irrigated Area	Total Cost ($/Field†)	Cost/ha ($/ha)	Total Cost ($/Field‡)	Cost/ha ($/ha)
O	50.6	14.2	64.8	40,782	806	86,210	1,331
A	40.5	10.9	51.4	37,948	938	72,258	1,406
B	30.4	8.1	38.5	34,527	1,138	54,388	1,415
C	20.2	5.7	25.9	29,909	1,478	34,836	1,345
D	10.1	2.8	13.0	24,459	2,417	21,251	1,641
E§	25.9	6.5	32.4	34,050	1,315	45,606	1,408

* Areas in hectares.
† Includes underground pipe and electrical service and generator.
‡ 1.5 m dripline spacing.
§ Typical 65 ha field split into two equal rectangular parts, resulting in a 25.9 ha semicircle for the center pivot.

Table 1: Investment cost for various center pivot sprinkler and drip tape systems (refer to appendix A for field arrangements), An Economic Comparison Of Subsurface Drip and Center Pivot Sprinkler Irrigation Systems. *American Society of Agricultural engineers 14, 391-398.*

From the same analysis, it was concluded that the final net return, or profitability, is extremely sensitive to crop yield and crop prices, as well as the life span of the drip tapes. Based on an assumption that the drip tapes have a life span of 10 years and are used on a 65 hectare farmland of corn with corn prices of $118.11/Mg across all yields and price combinations, the drip tape will come out ahead of the sprinkler system. However, if the price of corn price drops to $98.42/MG for a yield up to 13.4 Mg/ha (whereas yields higher than 13.4 Mg/ha, the drip tape will be more profitable), the sprinkler system will come ahead in terms of profitability. With yields lager than 13.4Mg/ha the drip tapes is the cheaper solution, even at a crop price of $98.42/MG. One thing that must be considered is that this analysis used an assumption that the yields of the two systems are identical which may not always be the case. From the same analysis, the lifetime of the drip tape was also used to analyse the profitability, and it showed that for life spans less than 5 years (as it currently stands at the UBC farm), the profitability of the sprinkler system is higher in all cases compared to the drip tape system. This profitability analysis does not include the extra labour cost incurred with management of the drip tape system such as seasonal removal and storage of drip tapes and repair.

As mentioned before, the profitability is very sensitive to crop yields and research has been done by multiple institutes to identify various affects of drip tape on crop yield. One study by the University of California investigated lettuce diseases and yield under subsurface drip and furrow (approximate comparison to sprinkler system) irrigation. The experiment was performed in the spring and fall seasons of 1993 to 1995 in the Salinas Valley in California. Plants were inoculated with *Sclerotinia minor, Bremia Lactucae, and Rhizomonas suberifaciens* (Lettuce drop, downy mildew and corky root respectively). The results showed a reduced severity of corky root and lettuce drop, and no noticeable difference of severity of downy mildew for the subsurface irrigation system. As well, this system produced higher yields than the furrow system. Another paper by the Gujarat Agricultural University in India showed experimental results of subsurface flood irrigation and drip tape with and without black plastic mulch of sugarcane trash mulch in the fields of Western India (1989 – 1991) for tomato crops. Results of this experiment showed highest fruit yield with drip tape in combination of sugarcane trash mulch. Although the flood irrigation is not a identical to traditional sprinkler systems, an approximate comparison of the flood irrigation and sprinkler system can be made in terms of water usage and delivery method (overhead).

Overall, it can be said that the drip tape system will generally yield equal if not higher yields than sprinkler system, and therefore the profitability of drip tape irrigation will always be higher for fields of 20 ha or smaller. Conversely, it is also safe to say that for very large fields of crops the sprinkler system will be more profitable.

When considering water usage, the cost of water in Metro Vancouver is relatively cheap compared to the rest of the world and water to the UBC farm city water and does not require extra filters and processing. Thus, the economic analysis for water consumption of the technologies was not deemed to be a contributing factor to the overall cost of both the drip tape and aluminum setup.

6.0 CONCLUSION

With the three sustainability criteria or dimension in mind, a final decision can be made on the most sustainable option for the irrigation system at the UBC farm. As it stands from the compilation of research and reports, the drip tape system appears to be the superior choice of irrigation system at the UBC farm. The saving of water is evident and will increase social awareness of green technology and sustainable development. Furthermore, for small scale farms such as the UBC farm, the net return of using drip tape can be economically profitable compared to the sprinkler systems given that proper care and management of the drip take is carried out. The only downside to using the drip tape is the fact that it is not recycled as much as it can be, for both economic and feasibility in terms of distant traveled and labour involved with recycling the drip tapes. The hope is that with proper care the life of the drip tape can be extended, and with the development of bio-degradable plastics the environmental impact of the technology can be reduced.

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APPENDIX A

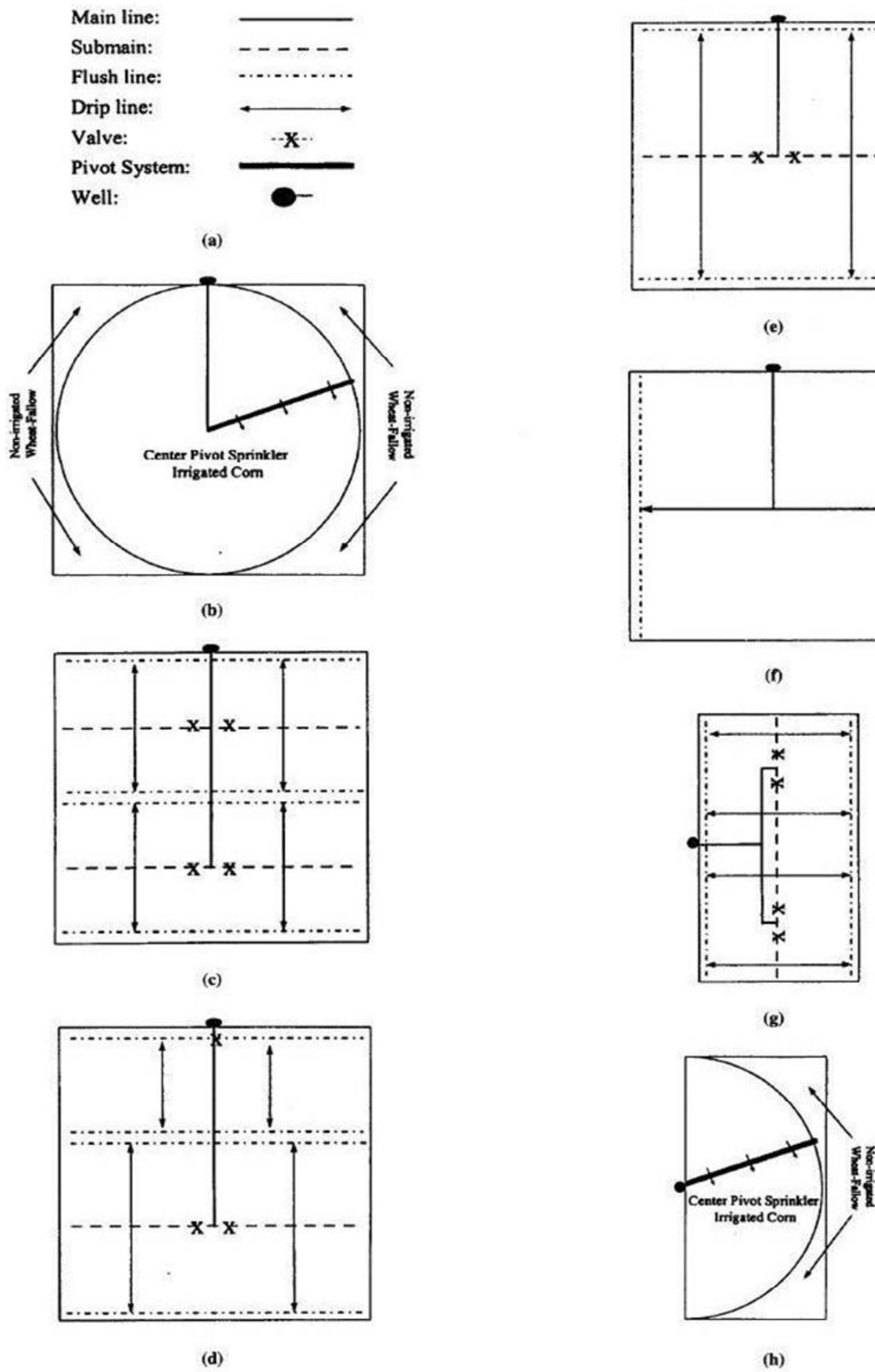

Figure 1: Designs for SDI and Center pivot sprinkler irrigation systems, An Economic Comparison Of Subsurface Drip and Center Pivot Sprinkler Irrigation Systems. *American Society of Agricultural engineers 14, 391-398.*