Abstract

Fields precision leveled to a zero grade require significantly less applied water and provide significant savings in annual production expenses relative to contour levee rice fields. However, zero-grade is a land improvement and requires a large initial capital investment. This study uses a Net Present Value (NPV) approach to evaluate the monetary benefits of zero-grade rice production for tenants and landlords under alternative rental arrangements. Results indicate both parties can gain positive monetary benefits under most lease structures in the long run but may experience short run monetary losses if yields decline during the initial years after the land improvement.

Economic Analysis of Zero-Grade Rice and Land Tenure

By Jeffrey A. Hignight, K. Bradley Watkins and Merle M. Anders

Introduction

Arkansas is the largest rice growing state in the U.S. and rice is the most water intensive program crop accounting for 70 percent of the total volume of water used within the state (Scott et al., 1998). A decrease of the state rice acres has occurred during the past few years due to many factors which include escalating irrigation costs. Factors influencing irrigation costs include energy source used for pumping, depth of pumping and field topography. A survey initiated in 2002 revealed that 55 percent of Arkansas rice acres were irrigated using a conventional contour levee system (Wilson and Branson, 2006). During 2006, Mississippi zero-grade fields used 38 percent less water than contour levee fields (Powers, 2007). Similar comparisons have shown zero-grade fields can use up to 60 percent less irrigation water (Epting, 2004).

Precision leveled fields in Arkansas account for an estimated 45 percent of rice fields with 5 percent of planted acres classified as zero-grade in 2005 (Wilson and Branson, 2006). Precision leveled fields improve irrigation and machinery efficiency, increase yield by as much as 10 percent, improve labor usage, improve water depth management and increase land values (Williams, 2004). Additional benefits come from better seed germination and efficient application of agrochemicals (Tran and Nguyen, 2007). Irrigation cost savings are generated by lowering the volume of water needed while increased machinery efficiency comes from reduced costs and time during planting and harvesting. While grain yields might increase over time, studies have shown that yields in cut areas can be lower than filled areas in a field (Walker et al., 2003). Over time, yield variation between cut and filled areas within a field decrease as organic matter increases in the cut areas (Walker et al., 2004).

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Large up front capital costs are required when land improvements are made. Capital expenditure incentives for land improvements have been made by federal government programs such as the Environmental Quality Incentives Program (EQIP) and subsidized loans at three percent interest rate made available for Arkansas cropland from the Arkansas Natural Resources Commission. Tax credits are also available from the State of Arkansas on 10 percent of the costs with a maximum credit of $9,000 per year and an option of capitalizing the costs of land improvements or writing it off as an expense for federal tax purposes. Short-term payoffs may not be reached under situations of short-term yield loss but may pay off long-term. Watkins, Hill and Anders (2007) determined that net present values are larger and payoff periods shorter for zero-grade fields when rice is grown continuously rather than rotated with soybeans following land improvement.

Approximately 80 percent of Arkansas rice acres are owned or partially owned by someone other than the producer (USDA-NASS). Therefore, landlords decide whether or not land improvements are made. Rainey et al. (2005) surveyed landlords and determined that factors such as age, location, risk aversion and managerial ability may influence the contract between landlord and tenant. This study found that the average age of a landlord was 68 years. This one factor alone could discourage some landlords from improving their land, particularly if they are seeking short-term cash payoffs on capital investments. Lease arrangements are typically year by year, and may keep some tenants from renegotiating unless sufficient length is provided within the lease to allow the tenant enough time to recover any short term loss of income due to yield loss risk. A strong working relationship between landlord and tenant would benefit both parties and allow both to carry some of the risk that is involved in land improvements.

The purpose of this study is to determine the implications of land tenure arrangements on the costs and benefits from zero-grade rice land improvements for both tenant and landlord. The objectives are: 1) compare costs and returns between contour levee and zero-grade rice; and 2) compare net present value (NPV) of alternative land tenure arrangements for the tenant and landlord.

These scenarios are calculated assuming a 10 percent yield gain, no gain and a 20 percent yield loss with the yield returning to the pre-improvement yield in year six. Agronomists helped determine the range of yield possibilities after land grading based upon their experiences. Returns are calculated on a per-acre basis for both tenant and landlord using the above indicated scenarios that might occur with zero-grade land leveling. The estimated NPV is based upon the difference between returns under the rice/soybean rotation with contour levees and continuous rice after the land improvement. Land tenure is also analyzed in the NPV by estimating the difference in returns under a specific lease arrangement before the land improvement and the returns under a specific lease after the land improvement is made.

Cost of Precision Leveling

In calculating the costs associated with precision leveling we assumed that the field size is 40 acres and that custom hired work moved 350 cubic-yards of soil per acre (Table 1). Custom work can be determined on an hourly rate or by cubic-yards of soil moved. Distance soil must be moved and the volume of soil moved will influence the per acre costs of zero-grade. Local land-leveling businesses were contacted to determine a cubic-yard cost for zero-grade. A cost of $1.60 per cubic-yard of soil moved was used in this study, and the volume of soil moved was 350 cubic yards per acre, the economically feasible upper limit determined from conversations with farmers and farm managers.

A well-drained field is essential for zero-grade fields to be profitable. The cost of a drainage ditch around the 40 acre field is included in this study. A typical charge for a ditch would be $120 per hour with an operator digging 330 feet per hour. Drainage pipes were priced from local supply companies at $27 per acre or $1,080 per 40 acres. Establishing the cut and fill areas for land grading is assumed to cost $12 per acre.

An additional cost of land grading is the application of poultry litter to supplement the cut areas of a field. The University of Arkansas recommends one ton of litter per acre on the cut areas of a field. Applying poultry litter to cut areas increases yields for rice above areas without the application (Stevens et al., 2001; Wilson et al., 1998). Research shows that litter applications can be a good source of phosphorus and potassium with returns over $100/acre on deep cut rice fields (Young et al., 2003). Transportation cost for delivered poultry litter was determined using the Litter Link Spring 2008 delivery price to Stuttgart. A subsidy of $14/ton for delivered poultry litter to Stuttgart is available through the Arkansas Natural Resource Commission and is assumed to offset the application cost in this study.

Land touch-ups may be necessary every 8-10 years with leveled fields (Henggeler, Thompson and Pfost 1998). This analysis assumes husbandry is maximized and touch-ups occur every 10 years at the rate of $130/acre. This includes work to both clean the ditch and touch-up the field.

Landlords may be able to negotiate a lower cost for land leveling if a tenant owns dirt-pans but this analysis assumes custom work is used. Whole-farm projects such as on-farm reservoirs, underground pipe and tail-water recovery systems would also influence the benefits and costs of land improvements. These projects would add to the irrigation efficiency and economic benefits (Wailes et al., 2001) and could influence land tenure towards costs share arrangements when underground water is depleting (Hignight et al., 2005).

Comparison of Costs and Returns for Zero-Grade and Contour Levee Management

Production costs and returns for zero-grade rice and contour levee rice and soybeans are estimated using the Mississippi State Budget Generator (Laughlin and Spurlock, 2006) and are presented in Table 2. Production costs and returns in Table 2 could be defined as those for an owner-operator (e.g., one who both owns and operates the land) but would be split between the tenant and landlord depending on the terms of the lease arrangement. Crop yields assumed for contour levee rice and soybeans are a three-year average (2004-2006) for Arkansas County collected from the National Agricultural Statistics Service. Since yields are uncertain after precision leveling, three different scenarios are presented (Table 2). Zero-grade rice yields are presented as a 10 percent gain, 0 percent gain and 20 percent loss with yield recovering at 6.6 bu/year until reaching pre-leveling yield in year six. Projected five-year average prices for rice ($4.70/bu) and soybean ($8.67/bu) are used as expected prices in this analysis based on 2008-2012 projections from USDA Agricultural Projections to 2017 (USDA-ERS, 2008).

Zero-grade and contour levee systems both have unique management requirements and significant cost differences. Contour levee management typically uses intensive tillage, but tillage on zero-grade may cause the field to lose grade and form potholes causing a decrease in irrigation efficiency and productivity. Therefore, tillage is kept at a minimum. Field preparation, planting, irrigating, and harvesting cost are higher under the contour levee system than zero-grade. Labor time for all field operations decreases significantly with zero-grade. Irrigation and harvesting efficiency is maximized under zero-grade management which lowers the costs for both field operations.

Fertilization for zero-grade continuous rice is slightly higher than the contour levee system. Under the contour levee-system, 150 lbs/acre of nitrogen are needed for the crop with an additional 20 lbs/acre needed under continuous rice production for the zero-grade system. Phosphorus and potassium requirements stay the same for both management systems. Agrochemicals for weed, insect, and fungus control are the same under both systems with the use of conventional rice varieties.

Net returns would be greater for both zero-grade rice with 10 percent and 0 percent yield gain compared to contour levee rice (Table 2). A 20 percent loss of yield would have a return of $7.46 per acre less than contour levee rice. The return for a rotation of rice and soybeans under the conventional contour levee system is $146.44 per acre for rice, $88.39 per acre for soybeans or an average rotation return of $117.42 per acre based on data in Table 2. Returns for a zero-grade field with continuous rice would be $371.63, $294.08 and $138.98 per acre for a 10 percent yield gain, 0 percent yield gain and 20 percent yield loss, respectively.

Lease Arrangements

Ten different scenarios are presented for the tenant and landlord in the following sections. An 80-20 straight share (ss) lease, a 75-25 straight share, a 70-30 straight share, a 75-25 cost share (cs) and a 50-50 cost share are presented. Under the straight share arrangement the landlord typically pays drying for their share of the crop and all well ownership expenses. The tenant would pay all production costs and be responsible for the irrigation power unit. For example, the 75-25 straight share arrangement would pay the landlord 25 percent of the crop as rent and the landlord would pay drying cost on that 25 percent. The 75-25 cost share scenario has the landlord paying 25 percent of the fertilizer and drying costs. The irrigation ownership cost is assumed to be the same as a straight share. The 50-50 cost share splits evenly fertilizer, agrochemicals and seed costs while splitting yield equally between tenant and landlord. The landlord would pay all energy pumping costs and the ownership costs of the well and power unit. The tenant would be responsible for all other expenses such as labor, machinery, etc.

Comparison of Monetary Benefits

Net Present Value (NPV) is the difference between the present value and initial costs for a particular time horizon measured in years. A discount rate of 6 percent is used in this study to determine the NPV for the tenant and landlord under alternative land tenure arrangements. The discount rate of 6 percent was used as a reasonable

estimate of the return that could be achieved from alternative investments. Based on advice from agricultural appraisers, the capital cost of the land improvement is assumed to be captured in increased land value. For example the total costs of zero-grading discussed in Table 1 would be approximately $829/acre. It is assumed that these costs would increase land value by $829/acre in a one-for-one fashion and offset the initial costs to zero in calculating NPV. While we assume each dollar invested would be a dollar increase in land value, it is not outside the realm of possibility to increase land value by more than the capital investment.

Discounted cash flows are based on the difference in the land tenure arrangement and yield expectation before and after land improvement. A rice/soybean rotation is assumed before the land improvement and continuous rice is assumed after the land improvement. Costs and returns are kept constant throughout the planning horizon to assume a real value on investment without inflation. Returns include direct payments for soybeans and rice and are divided between tenant and landlord according to the lease arrangement. Tenant and landlord NPVs are calculated before tax since there are a few tax options on the federal level. Expensing the costs may be the best option for some landowners while capitalizing the expense into the land value may create the highest tax savings for others. These options need to be carefully considered in the decision process. As discussed earlier, there are tax credits available in Arkansas for land improvements up to a maximum of $9,000 per year.

Tenant

Cumulative NPVs are presented for the tenant under alternative tenure arrangements and yield scenarios in Table 3. The results in Table 3 are presented for different lease arrangement starting points and assume either the same lease arrangement is maintained after the land improvement (80-20ss to 80-20ss in the first column of Table 3) or a different lease arrangement is used after the land improvement (80-20ss to 75-25ss; 80-20ss to 70-30ss, etc. in Table 3).

Positive benefits to zero-grade are realized for the tenant under all lease structures shown under both the 10 percent and 0 percent yield gain scenarios. However, the tenant could receive negative NPVs in the initial years following the land improvement under the 20 percent yield loss scenario. The tenant's NPV is influenced by the lease arrangement used before and after the land improvement. For example, a tenant with an 80-20 straight share arrangement prior to the land improvement would receive the largest NPV using the same arrangement after the land improvement regardless of yield scenario. However, if the tenant's starting arrangement is a 75-25 cost share arrangement before the land improvement, the tenant would be better off using a 50-50 cost share arrangement after the land improvement regardless of yield scenario. A tenant's NPV can also be influenced by the yield scenario itself. For example, a tenant with a 75-25 straight share arrangement before the land improvement would receive greater NPV maintaining the 75-25 straight share arrangement after the land improvement under the 10 percent yield gain scenario but would receive greater NPV moving to a 50-50 cost share arrangement under either the 0 percent yield gain or the 20 percent yield loss scenarios.

Landlord

Cumulative NPVs to zero-grade are presented for the landlord by rental arrangement and yield scenario in Table 4. The table presents the same scenarios as shown for the tenant in Table 3 but from the landlord's perspective. As with the tenant, the landlord receives positive benefits to zero-grade under all lease structures for both the 10 percent and 0 percent yield gain scenarios but could receive negative NPVs for some lease structures in the initial years following the land improvement under the 20 percent yield loss scenario. The landlord generally receives the greatest NPV by renegotiating for a larger share of the crop after the land improvement. For example, a landlord with an 80-20 straight share arrangement before the land improvement would receive progressively higher NPV by receiving 5 and 10 percent more of the crop after the land improvement regardless of the yield scenario. Similarly, a landlord with a 75-25 straight share arrangement before the land improvement would receive greater NPV by renegotiating to a 70-30 straight share arrangement after the land improvement regardless of yield loss scenario.

Renegotiating from a straight share to a cost share arrangement after the land improvement also increases the landlord's NPV in some instances. For example, a landlord with an 80-20 straight share arrangement prior to the land improvement would increase NPV by renegotiating to a 50-50 cost share arrangement after the land improvement for all yield scenarios analyzed. The same would be true for the 10 and 0 percent yield increase scenarios if the landlord had a 75-25 straight share arrangement before the land improvement but renegotiated to a 50-50 cost share arrangement after the land improvement. However, the landlord would be less well off moving from a 75-25 straight share to a 50-50 cost share arrangement for the 20 percent yield loss scenario (e.g., the landlord's NPV decreases when

moving from the 75-25 straight share to the 50-50 cost share for this yield scenario).

Summary

Zero-grade management provides significant savings in production costs and water volume use which is critical in areas where water is limiting. The volume of water needed for zero-grade is significantly less than for the contour levee system. A decrease in labor, machinery and fuel costs also adds to monetary savings. Average field yield after leveling is not certain. Some producers see gains in yield while others may experience short term decreases in productivity.

Land leveling feasibility becomes more complicated when both tenant and landlord are involved. Factors such as age, accessibility to capital, current lease arrangement, risk tolerance and opportunity costs of alternative investments factor into a landlord's decision for land improvements. Monetary benefits from the improvement for both tenant and landlord depend on the starting point for lease negotiations and productivity after land improvement. A tenant takes some risk depending on the lease structure and yield loss potential. Tenure arrangements that are renewed each year may limit a tenant's willingness to negotiate alternative lease arrangements that increase risk of reduced income.

Results from this study indicate that both parties gain positive monetary benefits from zero-grade under most lease structures. The tenant tends to gain the most monetary benefit when the terms of the lease agreement remain unchanged before and after the land improvement, while the landlord tends to receive the most monetary benefit by renegotiating for a larger share of the crop or in some instances renegotiating from a crop share to a cost share arrangement. The potential for yield loss after leveling to a zero grade can negatively impact both parties during the initial years following the land improvement. For instance the pre-leveling rental arrangement of 75-25 straight share renegotiated to a 70-30 straight share would create a negative NPV for both tenant and landlord in year one if a 20 percent yield loss occurred. In year two the landlord would have a positive NPV but the tenant would not see a positive NPV until year three. With a 20 percent yield loss, the tenant would lose the most renegotiating the lease from a 75-25 cost share to a 75-30 straight share. It would take nine years before the tenant gained a positive NPV under this scenario. A landlord would lose the most renegotiating from a 75-25 straight share to a 50-50 cost share if a 20 percent yield decline occurred. A positive NPV would not be achieved until year 12 under this scenario. Our analysis indicates that both parties can receive negative NPVs for some lease structures when yields decline by as much as 20 percent following the land improvement. However, NPVs eventually become positive with the passing of time. Therefore, zero-grade has the potential to increase the risk of yield and income loss for both parties in the short run but also has the potential to increase returns for both parties in the long run.

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Table 1. Zero-grade leveling costs paid by landowner

Item	Per acre ($)	40 acres ($)
Leveling by custom hire[x]	560	22,400
Drainage ditch[y]	165	6,600
Drainage pipes	27	1,082
Cut sheets and survey	12	480
Chicken litter[z]	55	2,200
Ten year maintenance	130	5,200

[x] Assumes 350 cubic-yards of soil moved at $1.60/cubic-yard.

[y] Assumes $120/hr for digging at 330 feet per hour.

[z] Poultry litter delivery price from the Litter Link website.

Table 2. Costs and returns with contour and zero-grade production systems

Economic item	Contour-levee rice	Zero-grade rice (10% yield gain)	Zero-grade rice (0% yield gain)	Zero-grade rice (20% yield loss)	Contour-levee soybeans
Crop yields, irrigation, and gross returns					
Yield (bu/acre)	165[x]	182	165	132	45
Irrigation (acre-inches)	33[y]	15	15	15	12
Gross returns ($/acre)	775.50[z]	853.05	775.50	620.40	390.15
Production costs and net returns ($/acre)					
Field preparation	48.47	4.68	4.68	4.68	44.40
Seed & planting	39.47	35.19	35.19	35.19	48.28
Irrigation & preparation	187.64	90.42	90.42	90.42	79.32
Fertilizer & applications	208.73	221.60	221.60	221.60	67.92
Chemicals & applications	62.56	62.56	62.56	62.56	25.04
Harvesting	53.46	44.57	44.57	44.57	25.27
Operating interest	28.73	22.40	22.40	22.40	11.53
Total costs	629.06	481.42	481.42	481.42	301.76
Net returns	**146.44**	**371.63**	**294.08**	**138.98**	**88.39**

[x] Three-year average Arkansas county rice and irrigated soybean crop yields for the period 2004-2006 are assumed for the contour fields. Zero-grade rice will be presented as a 10% gain, 0% gain, and 20% loss with yields recovering to post-leveling yields in year six.

[y] Rice and soybean irrigation levels are assumed to be average water use in Arkansas.

[z] Gross returns were calculated using the average rice price ($4.70/bu) and soybean price ($8.67/bu) from 2008-2012 found in the USDA Agricultural Projections to 2017 released in February 2008. Market prices are net of custom drying charges for rice ($0.30/bu) and custom hauling charges for both rice and soybeans ($0.15/bu).

Table 3. Cumulative NPV of zero-grade for a tenant under alternative land tenure arrangements and productivity

Planning horizon (years)	80-20ss[1] to 80-20ss[2]	80-20ss to 75-25ss	80-20ss to 70-30ss	80-20ss to 50-50cs	75-25ss to 75-25ss	75-25ss to 70-30ss	75-25ss to 50-50cs	75-25cs to 70-30ss	75-25cs to 50-50cs	50-50cs to 50-50cs
10% yield gain										
1	198	153	109	147	194	150	187	97	136	115
2	358	271	185	258	332	246	319	177	252	237
3	534	408	282	389	505	379	486	264	373	339
4	676	513	349	488	628	465	604	335	476	447
5	833	634	435	604	782	583	752	412	584	539
10	1,436	1,089	741	1,037	1,334	987	1,282	711	1,011	950
15	1,901	1,443	985	1,374	1,771	1,313	1,702	941	1,337	1,251
20	2,238	1,697	1,156	1,616	2,079	1,538	1,998	1,109	1,576	1,480
0% yield gain										
1	140	99	58	111	140	99	152	47	100	80
2	245	166	86	189	227	148	251	79	183	168
3	369	254	138	289	351	236	386	121	272	239
4	463	313	163	358	429	279	474	149	346	317
5	574	392	209	446	540	358	594	187	426	381
10	983	665	346	760	911	593	1,006	317	735	674
15	1,303	884	463	1,010	1,212	793	1,338	422	973	886
20	1,532	1,037	540	1,185	1,420	925	1,568	495	1,146	1,050
20% yield loss										
1	24	-9	-43	41	31	-2	81	-54	31	9
2	41	-25	-91	65	36	-29	126	-98	62	44
3	104	6	-93	126	103	5	224	-110	115	77
4	158	28	-101	172	144	14	288	-116	166	131
5	251	90	-71	249	238	77	397	-94	235	184
10	660	363	67	563	609	312	809	36	550	477
15	980	582	184	813	910	512	1,141	141	791	689
20	1,209	735	261	988	1,118	644	1,371	214	967	853

[1] Lease arrangement pre land improvement for column is 80-20ss (ss = straight share and cs = cost share).

[2] Lease arrangement after land improvement for this column is the same as pre land improvement.

Table 4. Cumulative NPV of zero-grade for a landlord under alternative land tenure arrangements and productivity

Planning horizon (years)	80-20ss[1] to 80-20ss[2]	80-20ss to 75-25ss	80-20ss to 70-30ss	80-20ss to 50-50cs	75-25ss to 75-25ss	75-25ss to 70-30ss	75-25ss to 50-50cs	75-25cs to 70-30ss	75-25cs to 50-50cs	50-50cs to 50-50cs
10% yield gain										
1	15	60	104	66	19	63	26	116	78	98
2	101	188	274	200	126	213	139	281	207	222
3	115	241	367	259	143	269	162	384	277	309
4	191	354	518	379	239	402	263	531	392	420
5	203	402	600	431	254	452	283	623	454	497
10	333	680	1,027	732	435	782	487	1,055	760	819
15	446	905	1,363	973	576	1,034	645	1,403	1,013	1,097
20	519	1,060	1,601	1,141	677	1,218	758	1,644	1,185	1,276
0% yield gain										
1	0	41	81	29	0	41	-12	93	40	60
2	72	151	230	127	90	169	66	237	134	149
3	72	187	303	153	90	205	55	320	170	202
4	136	285	435	240	169	319	125	448	253	281
5	136	317	499	263	169	351	115	521	285	329
10	215	533	851	438	287	605	192	879	466	525
15	291	710	1,130	585	382	801	256	1,170	625	708
20	336	831	1,326	682	448	943	300	1,369	726	818
20% yield loss										
1	-30	3	36	-47	-38	-5	-88	48	-38	-16
2	19	85	151	-5	23	95	-66	157	2	16
3	3	101	199	-20	3	108	-118	216	-3	29
4	56	186	316	42	70	212	-73	329	59	83
5	52	212	373	53	64	239	-95	395	80	119
10	131	428	725	228	182	508	-18	753	258	315
15	207	605	1,004	375	277	716	46	1,044	415	498
20	252	726	1,200	472	343	866	89	1,243	513	608

[1] Lease arrangement pre land improvement for column is 80-20ss (ss = straight share and cs = cost share).

[2] Lease arrangement after land improvement for this column is the same as pre land improvement.