Renewable Energy Development and Implications to Agricultural Viability[1]

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Abstract: Food and energy security have increasingly acquired key natural resource policy focus. As alternative energy solutions become more land intensive, the potential implication to the agricultural sector becomes of policy interest. This study investigated the impact of projected wind energy development in Michigan on the agricultural sector. Results indicate that land lease payments overtime for wind turbine siting are expected to generate $50 million per year, impacting agricultural viability. Spatial distribution analysis suggests that most of the projected lease payments to farmers are concentrated in low value agricultural land, low value agricultural production, urban influenced, and low net farm income locations. We found that the spatial distribution of wind energy impact on agricultural viability is wide, but significant in some counties, by a margin of more than 50% net farm income gain. As renewable energy development becomes more land intensive, the potential cross-sectoral impacts need to be carefully considered.

Key Words: agricultural viability, renewable energy, land use, spatial analysis.

Introduction

In the U.S. economy, energy supply and energy price volatility have played a significant role in determining the level of economic activity and, in some cases, business cycles (1). More recently, concerns on the economic, environmental and national security implications of energy sources have initiated significant interest in renewable energy sources, such as wind, solar, biofuels, battery technology, etc (2). As a result, many states have adopted numerous renewable energy legislation and mandates that would support the development of alternative sources of energy both for electricity and transportation purposes (3).

Increasingly, the social choice to meet traditional energy challenges through the development of alternative energy sources has relied on land resources (2). For instance, biofuels require significant amount of land to meet a certain percentage of transportation fuel supply from ethanol from such sources as corn and soybeans. Similarly, the production of electricity from alternative sources, such as wind energy, require significant amount of land to meet a given percentage of electricity supply. The long-term implications of such trade-offs between meeting energy challenges and utilizing significant land resources for renewable energy remains a debatable policy question. Recent hikes in global food prices, partly attributable to the use of agricultural land for biofuel crops, raises key questions regarding the tradeoff between long-term energy security and food security.

The interface between agriculture and energy, however, has potential contribution to agricultural viability (4). Agricultural policies in the past many decades have focused on providing policy support for agriculture to ensure the viability and sustainability of the agricultural sector in the U.S. The policy support for agriculture comes in many forms: through direct price support; farm credits; subsidies; and through agricultural land protection programs (5). Increasing agricultural viability through these policies has been extensively investigated in the literature, and the welfare implication and effect on long-term agricultural viability are explored. There is, however, limited study in the literature on the potential agricultural viability implications of the links between renewable energy development and viability of the agricultural sector.

This study primarily focuses on the links between wind energy development and implications to the agricultural sector. Due to current opposition to wind siting in high density areas, wind farms are often located in agricultural fields. If state identified potential wind development areas correlate with significant active agricultural lands, the implication on agriculture through lease payments and other impacts can be investigated.

Many states have introduced a Renewable Portfolio Standards (RPS) legislation to support the development of renewable energy, such as wind energy (6). RPS have been adopted in 30 states (7). RPS is a policy that mandates that a percentage or designated amount of electricity supplied by utilities be from renewable sources such as wind, solar, hydro, waves, water currents, and biomass (8). As more states consider mandated wind energy development, that significantly requires agricultural land, the potential implication to farm income and viability is of policy interest.

To understand the level of impact of wind energy development on agricultural viability, empirical frameworks are laid and implemented. First, following the study of Adelaja and Hailu (9), projected wind development in Michigan is identified based on their nation-wide econometric analysis of the determinants of wind energy development that included renewable energy, socioeconomic, demographic and political factors. MegaWatt (MW) coming from wind energy is projected until the year 2030. Second, projected MW wind development for Michigan is used to estimate impact on land lease payments to farmers until the year 2030. This is conducted by utilizing the Department of Energy JEDI software that estimates the impact of developed MW wind energy on jobs, income, and investment as well as land leases. Third, by utilizing GIS (Geographic Information System) spatial analysis, the spatial distributional impacts of wind development on agricultural areas in Michigan are identified. The implication of land lease payments from wind turbine siting on farmland on net farm income per acre and viability are also analysed.

This study adds to the literature in many ways. One, the fact that wind energy development is tied to agricultural income and viability invites a broader cross-sectoral look of emerging energy policies. Two, the study suggests alternative venues for supporting agricultural viability. Three, the multifunctionality of agricultural lands, often discussed from amenity value perspective, could be understood further from the perspective of renewable energy services. This study opens the window for broader research on the implications of future energy portfolio choices to agricultural lands and on the viability of agriculture.

Methodology

This study utilizes three methodologies to (1) estimate projected installed wind capacity in Michigan until 2030, (2) estimate the land lease payments to farmers (landowners) per year until 2030 to show the implications to farm income and viability, and (3) spatially identify the potential wind development areas in Michigan and analyze the distributional effects on known agricultural areas.

(1) Projected Installed Wind Capacity in Michigan: Adelaja and Hailu (9) estimated the determinants of installed wind power capacity in the U.S. and identified the key drivers of wind energy development. The study considered wind potential, renewable energy policy, socioeconomic, demographic and political factors. The study also projected installed wind capacity for Michigan till 2030. Table 1 provides the projected installed wind capacity in MegaWatts (MW).

Table 1. Projected Yearly and Cumulative Installations of Wind Capacity for Michigan in Megawatts (MW): 2004 – 2030.

	Projected Wind Capacity Installation	
Year	Total Predicted Annual Addition to Capacity (MW)	Total Predicted Cumulative Installed Capacity (MW)
2004	39.71	39.71
2005	40.00	79.71
2006	40.29	120.00
2007	40.59	160.59
2008	40.90	201.49
2009	780.00	981.49
2010	780.32	1761.81
2011	780.64	2542.45
2012	780.97	3323.43
2013	781.31	4104.74
2014	781.65	4886.39
2015	782.00	5668.39
2016	782.36	6450.75
2017	782.72	7233.48
2018	783.10	8016.57
2019	783.48	8800.05
2020	783.86	9583.91
2021	784.26	10368.17
2022	784.66	11152.83
2023	785.07	11937.89
2024	785.49	12723.38
2025	785.91	13509.30
2026	786.35	14295.64
2027	786.79	15082.44
2028	787.25	15869.68
2029	787.71	16657.39
2030	788.18	17445.57

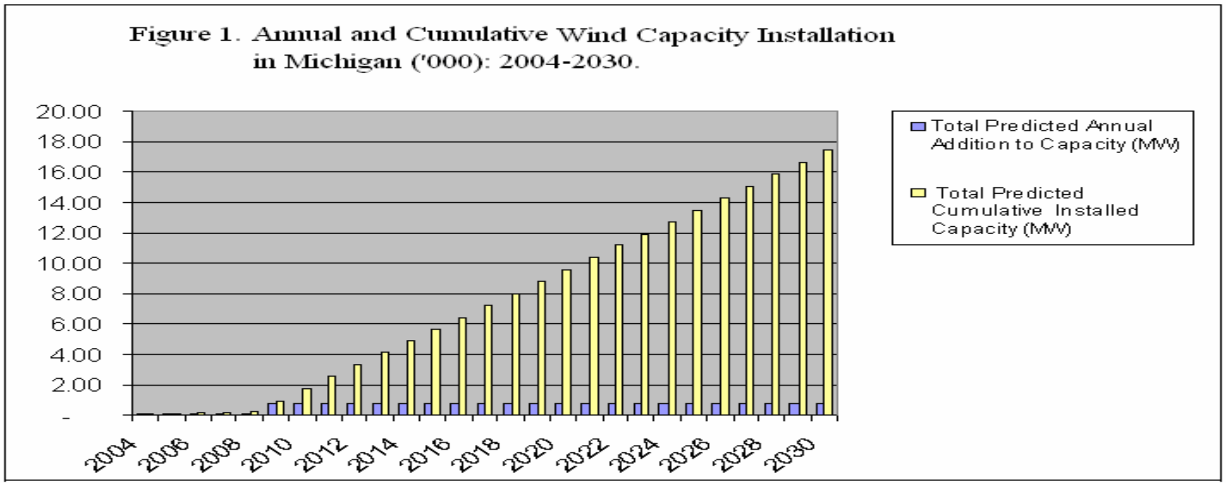
Source: Adelaja and Hailu (9).

(2) Estimating the Impact of Projected Wind Capacity Installation on Land Lease Payments: to estimate the impact of projected wind capacity installation in Michigan on land lease payments to land holders, the Department of Energy's JEDI impact assessment software is utilized. The multipliers indicated for the impact assessment from JEDI are: $1.6 million in construction investment per MW installed capacity, $2,689.27 in land lease payments per year, $0.18 permanent jobs per installed capacity, $263,362.60 in recurrent investment, and $27,091.95 in construction employment costs. The multiplier per installed MW for land leases is used as a base for estimating land lease payments for projected installations for Michigan.

(3) Spatial Distribution Analysis of Agricultural Areas and Identified Potential Wind Development Areas: to determine the distributional effects on agriculture of identified potential wind development areas in Michigan, first the potential wind development locations are identified. The Land Policy Institute at Michigan State University has developed a Wind Prospecting Tool that utilizes state wind potential, land values, exclusionary land uses, land use regulation, population density, and other variables to rate locations for wind development. It identifies high and low wind development potential spatial data. By integrating such potential wind energy development spatial data with agricultural area spatial data, the overlay between identified top wind development potential areas with agricultural lands provides the bases to determine the distributional impact of future wind energy development on agriculture. Analysis of net farm income with and without potential wind turbine land lease payments reveals the viability impact of wind energy development.

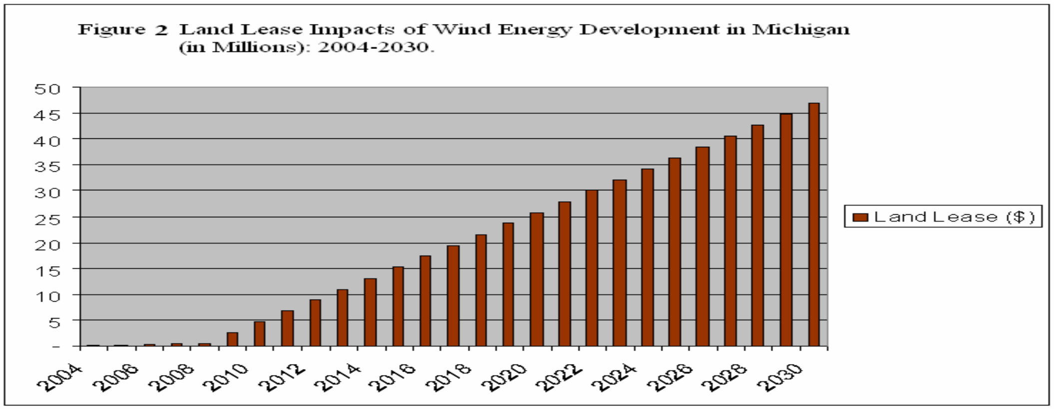
Results and Analysis

To determine the potential agricultural viability impacts of wind energy development in Michigan, first projected wind energy development is identified till the year 2030. Figure 1 summarizes the projected annual and cumulative wind capacity installation. The land lease payment impact for land holders is a relevant policy question.



Land Lease Impacts of Projected Wind Energy Development

Farmers and other land owners are expected to gain significant benefits from wind development land lease payments. For projected wind capacity installation, JEDI multiplier for land lease estimates is utilized to determine the projected land lease payments to land owners. Lease payments to farmers are estimated to range between $5 million in 2010 and $47 million in 2030 in Michigan. The current net farm income in agriculture in Michigan is approximately $724 million, and the projected land lease payments account to a relatively less but significant amount to net farm income. Figure 2 illustrates the land lease payments impact of wind energy deployment in Michigan.



Land lease payments are currently lower due to the limited expansion of wind energy in the state. Given the projected installed capacity, land lease payments are expected to grow significantly as indicated in Figure 2. The long-term land lease and agricultural income effects are thus apparent. Due to the uneven distribution of agricultural areas in the state, the estimated land lease payments will likely concentrate in areas where high wind potential corresponds to agricultural activity. Thus, the spatial distributional effects are important considerations.

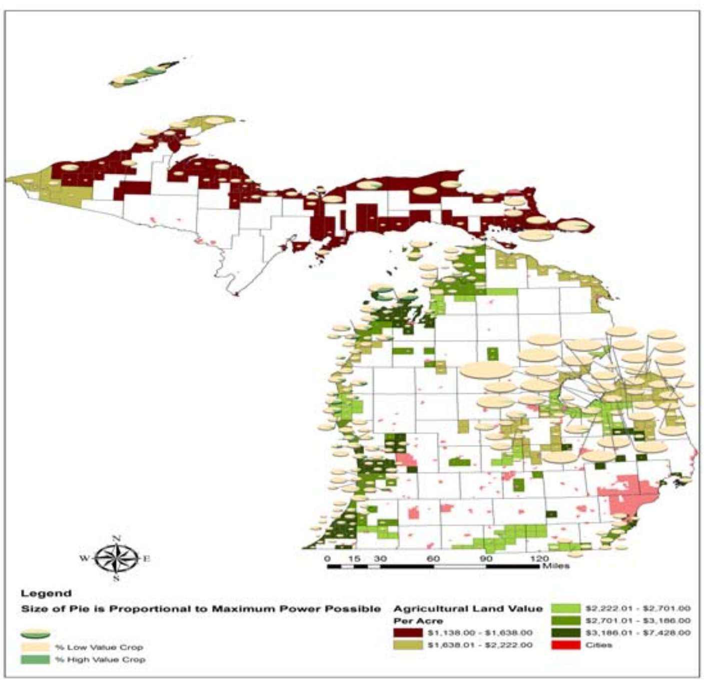
Spatial Distributional Impacts of Wind Energy Development on Agricultural Viability

The land lease impact analysis indicated that statewide, there will be a significant impact on land lease payments to farmers from wind energy development. Given the spatial disparity in the distribution of agricultural activities and wind potential areas, the distributional effects are important to consider. First, the potential wind development areas are identified using the Wind Prospecting Tool developed by the Land Policy Institute, Michigan State University. Second, active agricultural areas are spatially identified and jointly analyzed with spatial distribution of windy areas.

Spatial Distribution of Potential Wind Areas and Value of Crops

High value crop lands in Michigan are concentrated in the western to northwestern and southwestern edge of the state, indicated in Figure 3 as high value crop areas. Most of this area is fruit producing part of the state, generating high net farm income. Low value crops production is concentrated in the eastern part of the state, that has high density agricultural lands. The size of the pie in Figure 3 indicates identified high wind potential areas in MW. Figure 3 indicates that high wind energy development in Michigan is concentrated in low value crop lands. The concentration of high wind potential in core agricultural areas of the state characterized by low value commodity production (particularly in the southeastern part of the state) suggest that development of wind energy will have a significant impact to these agricultural locations. The agricultural viability impact in this case could be significant, as wind development related land lease payments and investments will concentrate in low value crop farming communities.

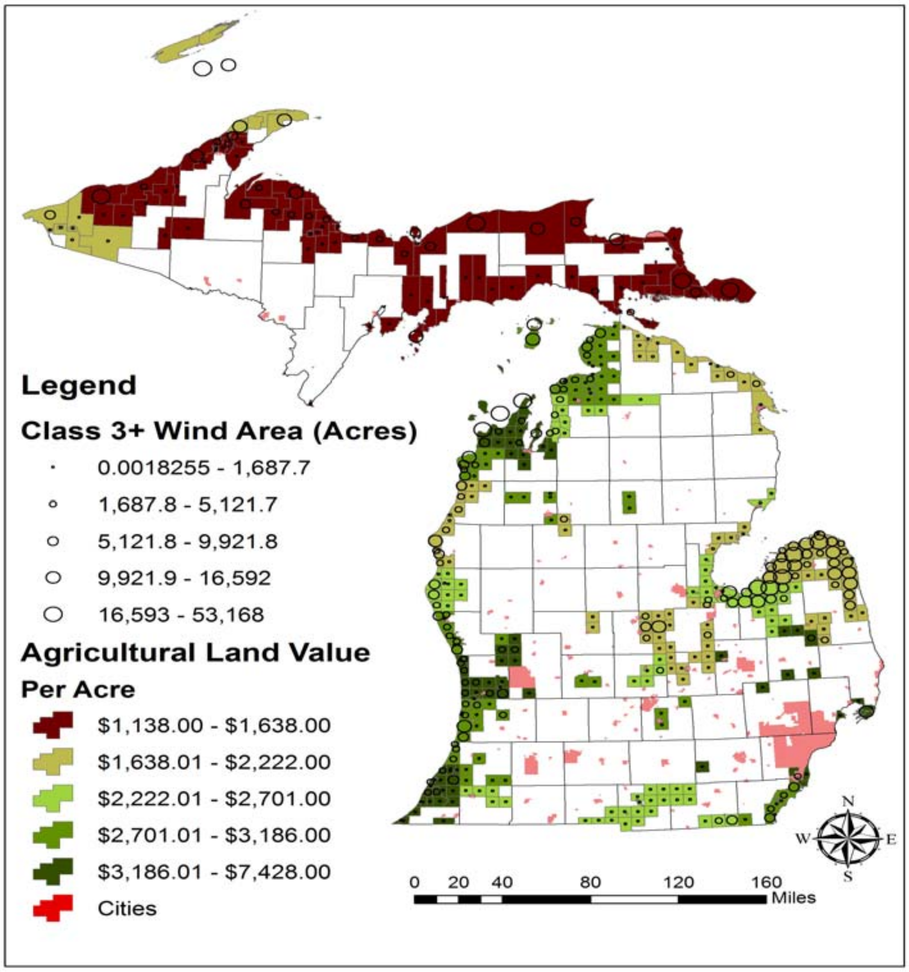
Figure 3. Spatial distribution of wind potential areas and agricultural areas by value of crops.



Spatial Distribution of Potential Wind Areas and Value of Agricultural Land

The spatial distribution of the value of agricultural lands per acre in Michigan is diverse. In general, as shown in Figure 4, the western coastal areas and southern part of the state have higher agricultural land value per acre, while the Upper Peninsula and eastern part of the state have relatively lower agricultural land values per acre. The spatial distribution of agricultural land values per acre also suggests that identified high wind potential areas are also located in relatively lower agricultural land values per acre areas. From agricultural viability standpoint, wind energy development can enhance viability in these locations through land lease payments.

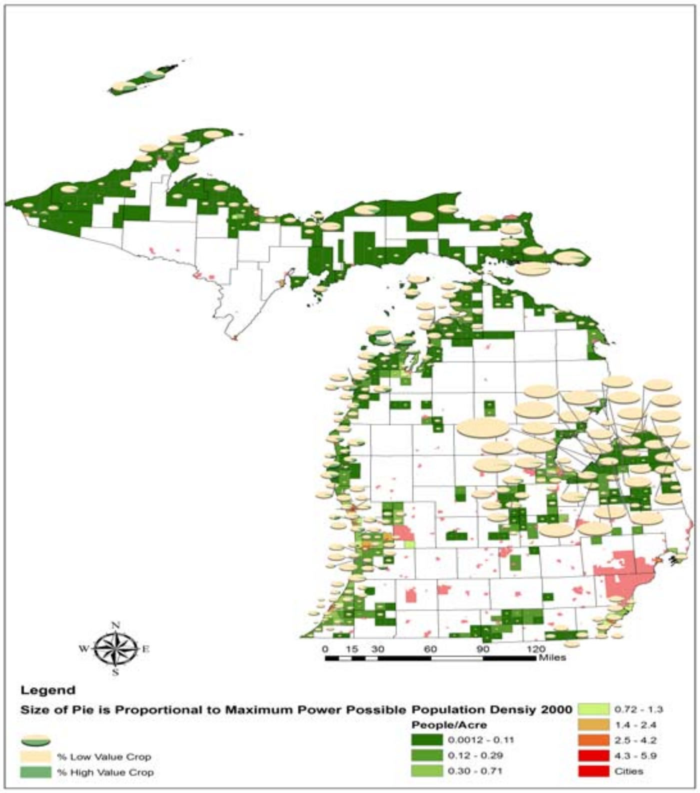
Figure 4. Spatial distribution of potential wind development areas and value of agricultural land per acre.



Spatial Distribution of Potential Wind Areas, Population Density and Agricultural Production

The spatial distribution of population density in Michigan indicates that population density is concentrated in the southeastern and southwestern part of the state where most of the farming activity is concentrated. The joint spatial distribution of population density and agricultural areas by value of crop production indicates that parts of the western and eastern agricultural activities face development pressure. This joint spatial correlation with wind potential area indicate that agricultural area threatened by development pressure also have high potential for wind development, and opportunity to generate land lease income. Given that land lease payments are estimated at $2,689/MW installed capacity/year, the potential viability and agricultural land retention impact of wind energy development could be significant.

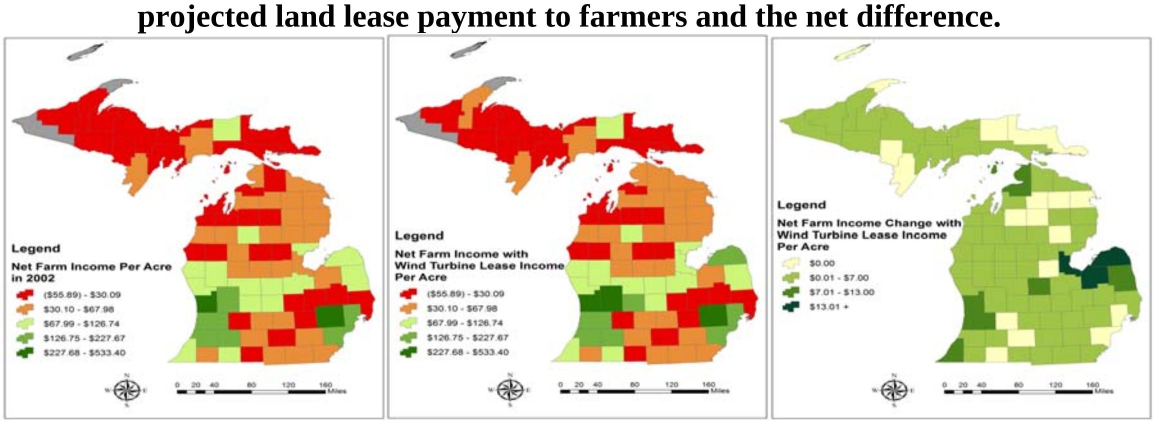
Figure 5. Spatial distribution of potential wind development areas, population density and agricultural production.



Spatial Distribution of Potential Net Farm Income with and without Wind Turbine Land Lease Payments

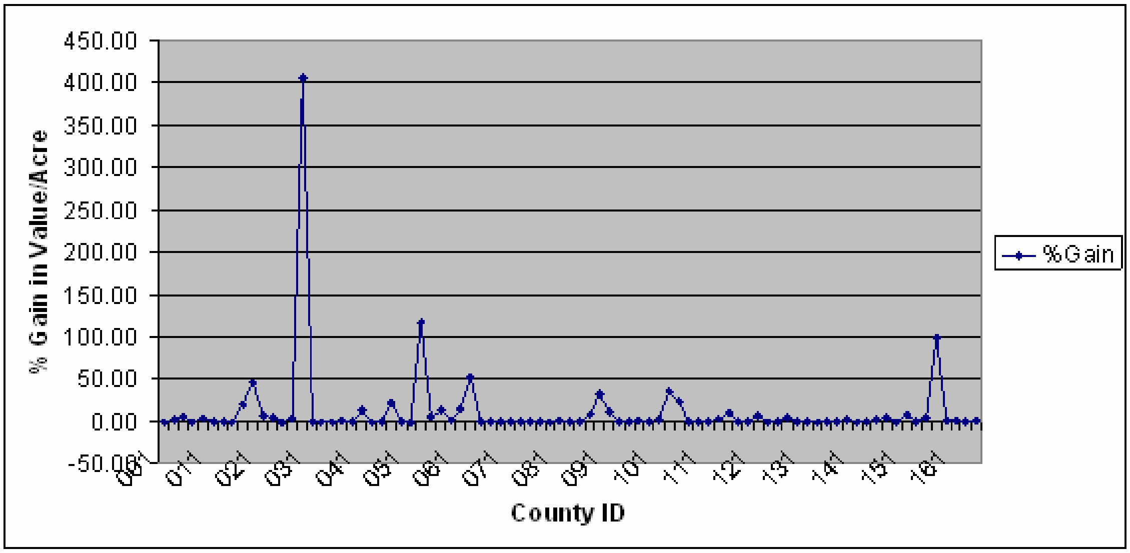
From an agricultural viability standpoint, one key determinant of viability is net farm income. The potential impact of land lease payments to farmers through wind turbine siting on farms on net farm income is one key measure of the impact of wind development on agricultural viability. Figure 6 indicates the spatial distribution of net farm income, which suggests that high net farm income locations in Michigan are concentrated in the western and some eastern counties. Integrating estimated land lease payments based on county wind potential and agricultural areas intersecting identified high potential wind areas, the result shows a shift in viability in some counties. Though the viability of many counties in post wind energy development remained almost the same, in some counties the effect of wind energy development is felt. This is due to two factors: one, high wind potential areas are concentrated in coastal counties in Michigan, and two, large tract farmlands are concentrated in select counties. The net farm income different in pre and post land lease payment period is also provided in Figure 6. It indicates that the per acre land lease payment impact on farms ranges from negligible to more than $56. This suggests that wind energy development will have a viability impact on agriculture, but more so in select high potential areas.

Figure 6. Spatial distribution of net farm income per acre with and without projected land lease payment to farmers and the net difference.



The percentage gain in value of land per acre by county is indicated in Figure 7. Clearly, the gains from land leas payments are significantly concentrated in select high potential counties. In these counties, estimated per acre value gain is significantly higher.

Figure 7. Per Acre Percentage Value Gain due to Land Lease Payments from Wind Turbine Sititng.



Conclusion

Food and energy security have increasingly acquired key natural resource policy focus. As alternative energy solutions become more land intensive, the potential implication to the agricultural sector becomes of policy interest. This study investigated the impact of projected wind energy development in Michigan on the agricultural sector. The direct impact of wind turbine siting on farmlands is the land lease payment to farmers. Based on projected wind energy development in Michigan, land lease payments to farmers are estimated to the year 2030. Results indicate that land lease payments overtime are expected to growth to $50 million per year, impacting agricultural viability. The study further conducted spatial distribution effect of wind energy development. Results suggest that potential wind development areas are located in low agricultural land value areas, low value agricultural commodity production areas, and in urban influenced agricultural locations. The correlation of these locations with high wind development potential in the state suggests the potential agricultural viability impact of wind industry development in these locations.

Estimates of agricultural viability through net far income is also considered. Results suggest that the net farm income impact of land lease payments from wind development have different impact distribution. While the agricultural viability impact of land lease payments in many locations is limited, due to less than $12/acre payments in most locations, in some counties the land lease impact on net farm income is quite significant and substantial. This suggests that the spatial distribution of wind energy impact on agricultural viability is wide, but significant in select counties (by a margin of more than 50% net farm income gain).

As renewable energy development becomes more land intensive, the potential cross-sectoral impacts need to be carefully considered. The interface between renewable energy and agriculture is significant, and need to be considered in evaluating energy portfolio choices and potential cross-sectral impacts.

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