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ORIGINAL ARTICLE

Drought adaptation in rural eastern Oklahoma in the 1930s: lessons for climate change adaptation research

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Abstract In the mid-1930s, eastern Oklahoma, USA, suffered an unusually harsh mixture of droughts and extreme rainfall events that led to widespread crop failure over several years. These climatic conditions coincided with low commodity prices, agricultural restructuring and general economic collapse, creating tremendous hardship in rural and agriculturally dependent areas. Using a previously developed typology of agricultural adaptation, this paper reports empirical research conducted to identify the ways by which the rural population of Sequoyah County adapted to such conditions. Particular attention is given to categorizing the scale at which adaptation occurred, the actors involved and the constraints to implementation. The findings identify successes and opportunities missed by public policy makers, and suggest possible entry points for developing adaptation strategies for current and future, analogous situations that may arise as a result of climate change.

Keywords Climate adaptation · Drought adaptation · Historical adaptation · Oklahoma droughts

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1 Introduction

Agriculturally dependent communities and regions are often viewed as being particularly susceptible to the impacts of climate change, which is understandable given the important role that climatic conditions play in agricultural production. Ever since discussion of the 'smart farmer-dumb farmer' assumptions made in many climate-impact scenarios began in the early 1990s (Smit 1991; Easterling et al. 1992), it has been accepted that the extent to which climate change will be detrimental or beneficial to agricultural producers and communities is significantly influenced by the success of those exposed in adapting to changing conditions (McCarthy et al. 2001). A body of scholarship has since developed to assess more closely climate impacts and adaptive options in many agricultural regions (e.g. Lewandrowski and Brazee 1993; Adams et al. 1995; Chiotti et al. 1997; El-Shaer et al. 1997; Luo and Lin 1999; Mizina et al. 1999; Bryant et al. 2000; Smit et al. 2000; You 2001; Leichenko and O'Brien 2002; Fuhrer 2003; Bradshaw et al. 2004; Liu et al. 2004; Maracchi et al. 2005; Motha and Baier 2005; Sivakumar et al. 2005; Wall and Marzall 2006).

One important development in the field of climate change and agriculture research has been a move from assuming adaptations and constructing scenarios around such assumptions to identifying actual adaptations and documenting the processes by which agriculture and farming communities adapt to climatic hazards and other conditions. This work recognizes that climate change will be experienced with many other stresses and adaptation will occur via processes already operating at various scales in agricultural communities (Kelly and Adger 2000; Schneider et al. 2000; Leichenko and O'Brien 2002; McLeman and Smit 2006a; Wall and Marzall 2006).

This article describes and analyzes the processes of drought adaptation that occurred in rural eastern Oklahoma, USA, in the 1930s. This area is located on the south-easternmost margins of the North American Great Plains, an agricultural region where future climate scenarios project an increased frequency of extreme heat events, a decrease in precipitation and a corresponding potential for declines in agricultural productivity (Rosenzweig and Hillel 1993; National Assessment Synthesis Team 2000; Reilly et al. 2003). In many respects such projections represent an exacerbation of existing climatic conditions in this region, where precipitation and average temperatures are already highly variable and drought is a regular occurrence (Woodhouse and Overpeck 1998). In the past century, severe droughts occurred across large parts of the Great Plains, notably in the decades of the 1910s, 1930s, 1950s, 1970s and 1980s (Lockeritz 1978; Hecht 1983). As recently as 2006, eastern Oklahoma experienced drought conditions that were meteorologically as severe as the infamous Dust Bowl years of the 1930s (Oklahoma Climatological Survey 2006).

An established way of examining prospects for adaptive behavior under conditions of future climate change is through the identification and examination of cases with spatially and historically analogous conditions (Glantz 1991; Mock 2000). Historical analogues uncover knowledge about vulnerabilities and adaptive behaviors and processes, providing important lessons for present-day policy- and decision-makers who are concerned with the ability of agricultural regions to adapt to impacts of climate change. Here we examine the variety of ways by which residents of Sequoyah County, a largely rural county in eastern Oklahoma, adapted to a period of particularly severe drought in the mid-1930s. Given the future climate projections for this region, it is worthwhile considering how populations in this region have adapted to past droughts, to identify constraints on adaptation and

opportunities for facilitating adaptation that may have been missed, and from these identify opportunities for enhancing future adaptive capacity. While the socio-economic and institutional conditions in 1930s Oklahoma differ from today, there are still a number of lessons that may be learned regarding how the process of adaptation plays out in the region's rural communities. Moreover, many of the non-climatic stresses and processes that influenced and constrained the adaptive capacity of 1930s Oklahomans are ones that prevail today in many developing regions elsewhere in the world. This examination of the actual processes of adaptation to changing climatic conditions that have occurred previously may provide transferable lessons about building rural adaptive capacity in other regions as well.

The research reported here was organized using a typology of farm-level adaptations to climate change developed by Smit and Skinner (2002), a typology that is consistent with work on adaptation done elsewhere (e.g. Downing et al. 1997; Mizina et al. 1999; Bryant et al. 2000; Kelly and Adger 2000). Using this typology, climate change adaptations in agricultural systems may be grouped in four general categories: technological developments, government programs, farmers' operational practices and farm-level financial management (Table 1). These groupings reflect understandings that adaptation may occur at a range of scales from a farm unit to the nation or beyond; may engage a range of actors from the individual farm operator to public agencies and corporations; may occur as planned or autonomous responses; and may take place over various periods of time. By using this typology, we were able to identify the actors and/or institutions involved in adaptation in this case study, the scale at which adaptation occurred, the consequences of the various adaptations for farm families and their communities, and the areas where opportunities may have been missed.

1.1 Case study: overview of Sequoyah County Oklahoma during the 1930s

Sequoyah County is found along Oklahoma's eastern border with Arkansas, in the southern region of lands formerly belonging to the Cherokee Nation (Fig. 1). Situated between the

Table 1 General agricultural adaptation typology (after Smit and Skinner 2002)

Scale of principal adaptation/ actors	Type of adaptation	Examples
System-wide/ public agencies, institutions, agri-business	Technological	– development of new crop types/hybrids
		– weather information systems
		– innovations for farm management such as pesticides, irrigation technologies
	Government programs	– crop insurance
		– subsidies and support programs
Individual farm unit	Farmer practices	– diversification/expansion
		– change timing of operations
		– change intensity of production
		– change location of crops on existing land
	Farm-level financial management	– purchase crop insurance
		– participate in futures market
		– participate in government programs
		– seek off-farm employment opportunities

Fig. 1 Location of Sequoyah County, Oklahoma

Great Plains to the west and the Ozark Mountains to the east, the county has a rolling topography. Its southern boundary is the Arkansas River flowing from west to east. The landscape becomes increasingly rugged moving northward from the river's wide floodplain and moving from west to east across the county. The most fertile land in the county is found in the floodplains of the river and along large creeks where run-off and flooding deposits organic matter, areas referred to locally as 'bottomlands'. The remaining lands in the county, making up more than 80% of the total, are a northern extension of a physiographic region referred to as the Ouachita Highlands (Gray and Galloway 1959). Originally covered by mixed forest of oak (*Quercus marilandica*, *Q. stellata*, *Q. velutina*, *Q. alba*), hickory (*Carya texana*, *C. tomentosa*) and pine (*Pinus echinata*), the thin soils of the upland regions are red-brown silty clay loams overlaying shale, with little organic material (Gray and Galloway 1959, Stahnke et al. 1967, Risser and Rice 1971). In many parts of the county, the topmost soil layers were rapidly exhausted after farmers introduced cotton (*Gossypium*), a crop that draws heavily upon soil nutrients. Exposed by forest clearance and plowing, the hilly topography and extreme rainfall events made soil erosion an early and ongoing problem.

In 1930, the population of Sequoyah County stood at 19,505, the majority of which lived in rural areas (all statistics this paragraph Historical Census Browser 2004). Just under half of the county's land was in farms (207,812 of 443,520 acres). There were 2,769 farms in the county. The size of farms was typically in multiples of 40 acres, the units used when the area was first surveyed because they divided equally into the standard of one square mile. The 40-acre unit had a practical aspect in this region, in that it also represented the cultivated area of row crops that could be farmed effectively using a single team of horses (*Equus caballus*) or mules (the offspring of a female horse and a male donkey (*Equus asinus*)).

While mechanical farm equipment was already widespread in Oklahoma by the 1930s, the hilly terrain and poorly productive soils of Sequoyah meant that mechanized farming was practiced only in the larger bottomland areas (McWilliams 1942; US House of Representatives 1940). Tractors were not widely used, and a reliable mechanical picker for cotton, Sequoyah County's main cash crop, would not be widely available until after the Second World War. Hence most farms were family-run operations, using human labor and draft animals (McWilliams 1942). Corn (*Zea mays*) was grown on most farms as a

secondary crop for animal feed. In addition to cotton and corn, most farmers kept for family use a small number of hogs (*Sus domestica*), chickens (*Gallus gallus*), geese (*Anser anser domesticus*) and a milk cow (*Bos taurus*) or two. A vegetable garden maintained by the farm wife typically rounded out the farm operation. Although beef cattle are today a main component of Sequoyah County agriculture, in that era prior to rural electrification there existed no ready means for preserving large amounts of beef, and cattle markets were too distant.

A distinctive characteristic of Sequoyah County farms of this period was that only 20% of farms were operated by the owner of the land (Historical Census Browser 2004). There are historical reasons why tenants constituted the vast majority of farm operators. The lands that today comprise Sequoyah County were originally allocated to Native Americans of the Cherokee Nation in the 19th century (Fig. 1), when much of what is now Oklahoma was set aside as Indian Territory (Morgan and Morgan 1977). At the time of European contact, most Cherokees were farmers who lived in permanent settlements east of the Mississippi, in what are today the states of Georgia, North Carolina and Tennessee. In the early 1800s, many of their lands were acquired by state governments through confiscations and dubious purchase agreements, and turned over to white farmers of European origin. Faced with ongoing pressure to surrender their lands, the Cherokees entered into a succession of treaties that exchanged their tradition lands for new land in present-day Arkansas and Oklahoma (McReynolds 1954). In the late 1830s the remaining Cherokees east of the Mississippi were forcibly removed to Indian Territory (Morgan and Morgan 1977). The Cherokees soon established farms and communities in their lands, and would hire non-natives as farm laborers and artisans.

In the decades following the Civil War, the US government, under pressure from non-native business interests, began a process of organizing Indian Territory to reduce native sovereignty and convert communally held tribal lands to a standardized land tenure system (Holm 1979). The Cherokees eventually submitted to pressure, and between 1903 and 1910 communal tribal lands were allotted to individuals, the size of acreages increasing with their degree of Indian ancestry (Hewes 1942). Land allocated to anyone with more than 2/4 Cherokee blood (i.e. two of his/her parents or grandparents were full-blooded Cherokees) could not be transferred to non-natives without approval from the Bureau of Indian Affairs. This led many full-blooded Cherokees to declare themselves to be only 2/4 or 3/8 blooded, meaning that they received smaller acreages but which came with a transferable title.

The allotment process fulfilled the underlying purpose of providing non-natives greater access to land in the former Cherokee Nation. The leasing of allotments brought thousands of new tenant farmers into the region, and by 1940 the majority of original Cherokee lands had been acquired by non-natives (Hewes 1942; Graves 1982). Corporate farming interests acquired the most productive lands along the Arkansas River by the 1920s, and used machinery and wage employees to work the land (Mayo 1940). This left a relatively dense rural population across the uplands of Sequoyah County, occupying a checkerboard of small, mainly tenant-operated farms on the least productive agricultural lands (McWilliams 1942).

With the collapse of American financial markets in 1929, Oklahoma's non-farming economic sectors—rail, mining and petroleum—immediately began a lengthy contraction and shed workers (Morgan and Morgan 1977). Sequoyah County experienced a subsequent influx of unemployed workers seeking tenant farms to operate, farming being the last remaining avenue for many to support their families (McLeman 2006). Because a tenant could rent not only the land but also draft teams and crop inputs from the landowner, it was possible to enter farming with little ready cash.

Throughout the 1930s, severe drought conditions reduced cotton yields and the quality of cotton lint harvested across Oklahoma. At the same time, commodity prices hit record lows, causing cotton farm incomes to fall precipitously (Fig. 2a, b). In 1936, the worst drought year of that decade, average cotton lint yields on Oklahoma farms fell to 62 pounds per acre, less than half the average yield on Texan farms, and two thirds of the cotton lint harvested was of inferior grades (Hedges and Nelson 1937).

Drought conditions struck Sequoyah County in the summers of 1932, 1934 and 1936, with the latter years being most severe. Summer rainfall in the county typically averages more than 10 inches; in the worst drought year, 1936, less than 1.5 inches fell all summer (USDA Weather Bureau 1936). Summer temperatures were extremely hot, with 100+ degree days being frequent. The loss of cotton and corn crops was total and complete across the county in 1936, and most farmers experienced significant or complete crop failures in 1932 and 1934. In 1935, extreme rainfall events caused heavy flooding and crop damage or loss in parts of the county. Of the 5-year period 1932–36, only in 1933 were growing conditions generally favorable for cotton and corn production.

These agroclimatic conditions to which Sequoyah County farmers were exposed during the mid-1930s are not anomalous, but may in fact be analogous to future climatic conditions to be experienced in the North American Great Plains and bordering regions. Low annual average precipitation levels, periodic droughts, extreme rainfall events and a generally high degree of climatic variability have been characteristic climatic features of

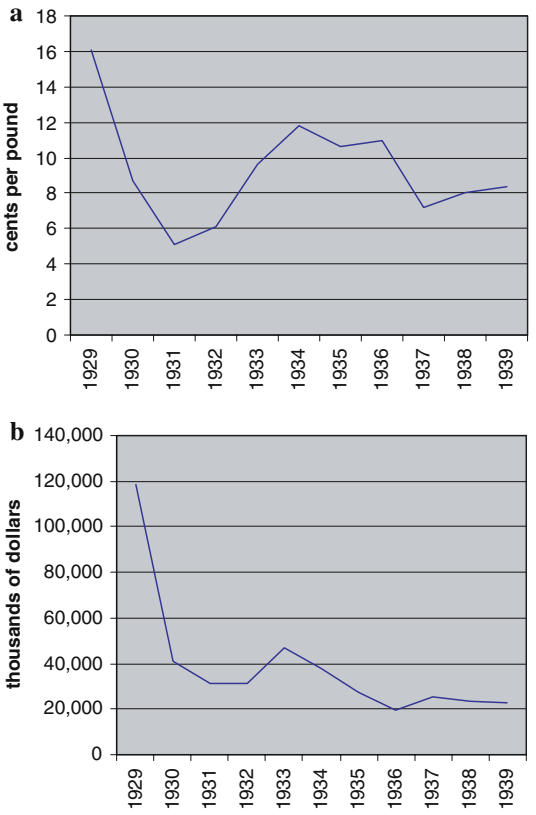

Fig. 2 (**a**) Average annual prices received for cotton lint in Oklahoma, 1929—1939 (Source: Collins and Hill 1958). (**b**) Gross farm income from cotton lint in Oklahoma, 1929–1939 (Source: Oklahoma Agricultural Experiment Station 1948)

this region throughout the 20th century (Borchert 1971; Lauenroth et al. 2000; National Assessment Synthesis Team 2000; Wilhite 2003). Paleoclimatic data suggests that the droughts of the 20th century may in fact have been shorter in duration than was typical of previous centuries, and future climate scenarios suggest a return to formerly high levels of aridity and drought severity (Woodhouse and Overpeck 1998; Nyirfa and Harron 2002; Sauchyn et al. 2003; Schindler and Donahue 2006). The impacts of 1930s droughts on agricultural systems and communities are therefore seen as analogs for understanding future climate impacts (Rosenzweig and Hillel 1993). Investigating the processes of adaptation in areas such as Sequoyah County during extreme climatic conditions therefore provides insights into how such processes might function under future climatic conditions in similar rural communities, and point to possible opportunities and constraints (McLeman 2006).

2 Approach and methods

The purpose of this study was to examine how residents of Sequoyah County adapted to the drought conditions of the mid-1930s. A variety of primary and secondary sources were used in data collection. The secondary sources consulted included government reports, census data, reports of rural sociologists at the Oklahoma Agricultural Experiment station, autobiographical writings, newspaper accounts and sources from the Sequoyah County Historical Society.

A Canadian-based researcher worked with local experts on two separate visits to Sequoyah County to interview local residents with firsthand knowledge of conditions in the county during the 1930s. Interviewees are of an advanced age and, given the amount of time that has passed, their numbers have become increasingly few. Potential interviewees were approached via local intermediary contacts and electronic recording equipment was generally not used, both measures taken to enhance interviewees' comfort and security with the interviewing process. Nineteen semi-structured interviews were conducted, with questions largely open-ended. Despite the passage of time and their advanced age, interviewees had particularly vivid recollection of that time, a reflection of the extraordinary degree of hardship that accompanied the droughts. Information given by interviewees was largely consistent with one another and with information gathered from secondary sources, suggesting that recollection bias is minimal. Immediately following interviews data were recorded in bibliographic software. Upon completion of all interviews, the information gathered from interviews and all other sources was tabulated and organized according to the Smit and Skinner (2002) typology.

3 Results

Commonly cited forms of adaptation and specific examples are summarized in Table 2. It should be noted that the term *adaptation*, which is commonly used today by climate scientists, is recognized by Sequoyah County residents but is not the term they would typically use to describe their experiences during the 1930s. A much more commonly used description was that people did what they could *to survive* the 1930s. This use of the verb 'to survive' provides the outsider observer a much clearer picture of the criticality of the household's responses to conditions in the 1930s than is conveyed by the more neutral, detached term 'to adapt'.

Table 2 Adaptations in rural Sequoyah County to drought in mid-1930s

Category of adaptation	Examples	Comments	Constraints on adoption
Technological	Land terracing	– practice encouraged by soil conservation agents; not widely adopted	– few farmers owned land, no return to tenant operator in improving land
Government programs	AAA subsidies	– encouraged farmers to cull herds, reduce acreage of cotton crops in exchange for payments	– payments were most beneficial to landowning farmers; no incentive for tenant farmers to participate – some evidence of coercion by government agents
	WPA employment	– WPA jobs were widely sought by many members of rural community, regardless of tenure/occupation	– demand for WPA work exceeded available jobs – some evidence of nepotism among local WPA administrators
	CCC jobs	– often used by elder sons as means of contributing to family income; worker received $5/month living allowance, another $25 was sent directly to household	– jobs were typically in areas distant from Sequoyah County; employment might only be for a few months duration
	FSA commodity trucks	– trucks would travel around county distributing free non-perishable items	– social stigma was attached to accepting supplies as distribution occurred in public
Farm practices	Increased reliance on farm women's labor	– raised more chickens, eggs then bartered for essentials; cream sold to dairy; increased amount of canning	– women had already been significant contributors so increase was marginal
	Pool labor with family/ neighbors	– done for large tasks like butchering pigs for hams, bringing in crops; may share farm with extended family members	– depended on having extended family in same region or close ties with neighbors; served to reduce employment opportunities for others
Farm financial management	Abandon farming/migrate elsewhere	– decision may not be voluntary depending on nature of tenure	– significant costs to leaving region meant option not available to all
	Obtain store credit	– most lending institutions had closed during Depression	– required being of good standing in community; interest rates could be prohibitive
	Barter	– common practice as cash became scarce	– required being of good standing in community; could only be done for basic staples
	Seek off-farm employment	– the few local opportunities included such things as trapping, some harvesting work	– traditional seasonal labor destinations in region had little demand for workers
	Black market activities	– corn-whisky stills on most farms; some smuggled alcohol across state lines	– provided only a small income supplement in most cases

3.1 Technological adaptations

One perhaps surprising finding that stands out is that essentially no technological adaptations were implemented on Sequoyah County farms during the drought years. Most farmers continued using crop types and equipment that had been in place since the time the land was first cleared for agriculture. This is not because no technological advances were being made in agriculture generally during this period; on the contrary, in other parts of the United States such as California farm operators were adopting new mechanized equipment, investing in irrigation systems and planting an ever-increasing range of crop types. It would not be until after the Second World War that significant changes would take place on Sequoyah County farms, such as the conversion from row crops to beef cattle production and the increased use of mechanized equipment in farm operations. Even relatively simple and inexpensive technological improvements like terracing sloping fields to prevent erosion and increase soil moisture content were not widely adopted during the droughts.

There are several reasons why technological innovations were not adopted during the drought years. The most obvious is that, during this period of falling yields, farmers simply had no money to invest in technologies like mechanized equipment or irrigation systems. In the preceding years of low commodity prices and macroeconomic instability farmers had difficulty raising funds for equipment during years with good harvests, so it was highly unlikely they would find the money after bad harvests. Most drought-stricken farmers considered themselves fortunate if they were simply able to save enough money to purchase essential clothing and supplies to get through the winter and have money left over to buy seed in the spring.

The lack of interest in land terracing is symptomatic of a larger process whereby eastern Oklahoman farms tended to lack even the most basic improvements made on farms elsewhere in the state and in other states (McDean 1978). Farm tenancy rates in eastern Oklahoma had been very high for many years. Farm tenancy agreements were typically made on a handshake basis (i.e. without a written contract) for 1 year at a time (Coleman and Hockley 1940). The agreement could be revoked by the landowner with three days' notice. Even tenants who had successfully operated the same farm land for many years had no greater degree of security. Because of the severe economic recession and unemployment in other sectors of the Oklahoma economy, a perverse dynamic had emerged whereby the demand for tenant farmland in counties like Sequoyah was increasing, even as yields were falling and government programs were encouraging reductions in cotton acreage. This led to landowners demanding 'privilege money' from prospective tenants, an up-front cash payment on top of the usual tenancy terms (Southern 1939).

This lack of security among tenants meant they invested little labor in making improvements to the land they operated, since increasing the productivity and hence value of the farm might simply increase their chances of not being able to renew their lease the following year. Instead, tenant farmers worked their exhausted and desiccated land as intensely as they had in previous years, causing high levels of soil erosion and accelerating the degradation of farm land. Even today, 60 years after the last cotton was harvested in Sequoyah County, former tenant farmland (referred to locally as ''wore out ole cotton land'') that is now used for grazing cattle may require high levels of fertilization, seeding of nitrogen-fixing plants and ongoing management to ensure productivity as pasture.

3.2 Government programs

Government programs, on the other hand, quickly became essential mechanisms for adaptation for a wide section of the population. In one sense, Sequoyah County was fortunate in that, unlike western parts of the state, the worst droughts of the decade did not occur until after the administration of Franklin Roosevelt came to power in 1932. The previous administration under Herbert Hoover had refused to implement public-funded relief programs early the Depression, preferring to leave such activities to charities like the Red Cross (Benedict 1966). By the time the 1936 drought was bringing Sequoyah County to its knees, many of Roosevelt's New Deal programs were up and running.

Three of these programs proved critical to Sequoyah County residents: the Agricultural Adjustment Act (AAA), the Works Progress Administration (WPA) and the Civilian Conservation Corps (CCC). An important feature to note is that none of these problems was specifically designed with drought relief in mind, and that they operated throughout the United States, not just in drought-stricken states like Oklahoma. This helps explain why each program offered some adaptation assistance to drought-stricken farmers but none was universally effective. The universality of such programs might also suggest why their implementation was achievable in a public policy sense, because they were driven by a sense of a national emergency and were not driven by regional or sectoral interests alone.

The AAA underwent various incarnations during the 1930s. It was originally conceived as a means of stabilizing commodity prices that by the end of the 1920s had fallen to record lows (Saloutos 1982). Most agricultural products that were traded in any large volume were subject to AAA, including cotton, Sequoyah County's most important crop. Under the AAA, farmers were offered compensation for reducing their total acreage of land in cotton production. Because most cotton farmers in Sequoyah County were tenants, they had no interest in reducing their acreage for what would amount to a one-time payment. Moreover, AAA payments were notoriously slow, meaning that a farmer may well have to move on to another place before receiving payment. The structure of early AAA payments was based on reducing acreage, not yield. Hence a landowning farmer could evict tenants from his land and use AAA money to intensify production on his remaining operational land (Lange and Taylor 1939).

The WPA had the greatest effect on adaptation in the drought-stricken areas. Under the WPA, local governments across the US, rural and urban, could apply for funding for projects to build or upgrade infrastructure. Across Sequoyah County, roads were paved, drainage culverts and bridges were built, and schools and community centers constructed using WPA funds. Pre-cast concrete toilet buildings were built and distributed. Even in the remotest corners of Sequoyah, such as the northeastern hamlet of Nicut where fewer than ten houses were scattered along a quarter-mile of creek bottomland, WPA-funded projects provided work resurfacing dirt roads with gravel. WPA projects in Sequoyah County provided straight hourly wage jobs as well as paying for suppliers of draft teams and trucks and for services like hauling building materials. Despite the federal government's largesse, the jobs created by WPA projects rarely provided work of more than 18–20 hours per week. Demand for WPA jobs exceeded their availability, and in both firsthand and secondary accounts there are accusations of nepotism against the local administrators who managed WPA funds and awarded employment contracts.

CCC projects employed people in forestry or park-related activities. Because work sites were often located in remote locations in other states and required extended periods of absence from home, CCC employment was most commonly taken by older children, not by heads of households. CCC work usually paid $30 per month, $5 of which was kept by the

employee, the remainder automatically remitted back to the household. Combined, the WPA and CCC provided many eastern Oklahoman households with supplemental wage income at a time when off-farm employment opportunities in the region were extremely scarce.

A fourth group of national assistance programs came into effect in 1937 under the Farm Security Administration (FSA), the year following the worst of the eastern Oklahoma droughts. FSA programs were intended to help with the social fallout and rural poverty that were legacies of years of economic depression and droughts. Programs operated by the FSA ranged from providing loans and subsidies to distressed farmers, to managing camps for migrant agricultural laborers in California, to distributing staple items free of charge to drought-stricken rural areas. Demand for FSA loans far outstripped their availability, and indeed we encountered no respondents in Sequoyah County whose families received one. Displaced Oklahoman tenant farmers were the single largest group of residents in FSA migrant camps in California, and farmers from Sequoyah County and neighboring counties numbered among them (Holzschuh 1939). In the case of those who adapted by leaving Oklahoma, it can be said that the FSA played an important role in their adaptation. The most common contact Sequoyah County residents had with the FSA was through the FSA-supported ''commodity trucks'' that distributed staple items like powdered milk, eggs and so forth free of charge. A social stigma was attached to taking this form of charity, and a local story recalls the starving farmer who refused supplies from the FSA truck, telling the driver to ''take that stuff on down the road where there's poor folk who need it''. More likely, however, a child would be sent to collect the free supplies on behalf of the household, thereby avoiding the shame of an adult being seen by the neighbors accepting charity.

3.3 Changes in farm practices

Not only did farmers not adopt new technologies to cope with drought, farmers also made few changes to their established practices. Farmers did not alter the location of crops on their land, since they had already long arranged corn and cotton plantings such that corn, the less drought-tolerant of the two crops, was planted in those fields or parts of fields with the highest soil moisture content. Switching away from cotton and corn to more drought-tolerant row crops like grains was not possible for numerous reasons. Although it was not well suited to dry conditions, corn could not be abandoned because it was needed to feed draft animals and livestock. Grains could not be grown profitably with a draft team, and most Sequoyah County farms were in any event too small to derive enough cash from grain to support a family. The rural infrastructure that supported farmers—from feed stores to gins—was geared to cotton production. Finally, cotton farming was what Sequoyah County farmers knew and did best.

The main changes in farm operational practices can best be described as an intensification of existing practices. For example, there had always been a high degree of cooperation among residents of rural communities. Friends, neighbors or extended families were regularly helping one another perform labor-intensive tasks, such as bringing in crops or slaughtering hogs. These practices became even more entrenched, since there was no money available to hire help when extra labor was needed. During the worst parts of the droughts, farmers sometimes pooled their money to import boxcar loads of corn shucks to feed their livestock when fodder ran out. This was a truly stopgap measure, since shucks (the leaves that encase a cob of corn) have little nutritional value as animal feed. In most such cases the cattle were eventually culled.

The importance of women's activities on the farm, already considerable even in good years, was magnified during the droughts. In some instances, the only activities that brought in any income were selling eggs or cream, activities performed by women. The family vegetable patch, which provided much of the family's food, was also typically managed by the farm wife. On the poorest farms, where the family could not afford to keep hogs or more than a few chickens, a type of cowpea grown in the garden and referred to locally as ''whippoorwill peas'' (*Vigna unguiculata* '*Whippoorwill*') might be the family's main source of protein for long stretches of time. Farm women had always canned or preserved fruits and vegetables; this activity intensified during the droughts, and women learned to expand the range of food types that might be canned. For example, when cattle were culled, to prevent losing the meat due to spoilage from lack of refrigeration, women canned it. They also canned sausages, frog legs and any other type of perishable food item that might opportunistically come available.

Throughout the 1920s, commodity prices had been steadily falling, and farmers had responded by attempting to raise yields through intensification of their operations. When the droughts came in the 1930s, most Sequoyah County farms were already being operated as intensely as possible, so these types of practices were of marginal benefit. As one interviewee noted, when asked how the onset of the Depression in 1929 affected farm operations, ''We didn't even realize there was a Depression, everyone was already in the same [bad] shape''. Hence when the droughts struck, there was little more that could be done to improve productivity or make changes in production to counter the effects of drought.

3.4 Farm financial practices

When cotton crops began to fail in the mid-1930s, cash immediately became scarce in Sequoyah County, since cotton was the main source of cash income on most farms. One of the first adjustments made was that barter replaced cash in many everyday transactions. Eggs would be exchanged for sugar or coffee at the local store; newspaper subscriptions would be paid for with cans of preserves. Barter was a useful mechanism to enable farms to obtain inexpensive or daily-need items, but could not typically be used for larger purchases such as seeds or equipment, or to meet financial obligations. In those cases, credit needed to be obtained.

Because of the 1929 financial crisis, many lending institutions that had once served eastern Oklahoma had closed a few years before the droughts struck. In Sequoyah County, only two banks remained by the mid-1930s. Those lending institutions that were still operating were very hesitant to lend money to farmers generally, and did not serve landless farmers at all. Most people therefore had to obtain credit from local merchants. For a merchant to extend credit to a farmer, the merchant needed to be satisfied that there was a reasonable likelihood that the debt would be repaid. Since merchants had no means of forcing a borrower to repay (with the exception of refusing future credit), a high degree of trust was required between borrower and merchant. The factors that gave rise to this trust included the length of the borrower's residence in the area, the extent of the borrower's family and friendship ties within the community and the borrower's past history of repaying debts.

This reliance on trust meant that not all farmers had similar access to merchant credit. Landowning farmers had typically resided in the area for extended periods of time and were unlikely to abandon their farms at a moment's notice, and so obtaining credit was

straightforward. Not all tenant farmers had similar access to merchant credit. The tenant farming population was inherently mobile; in any given year up to one-third of tenant farms might change operators (Southern 1939). Many tenant farmers had recently moved into the region from elsewhere. Such farmers might therefore have difficulty getting credit from merchants, or to obtain it might have to agree to interest rates of hundreds of percent annually, there being no usury laws in Oklahoma at that time (Moore and Sanders 1930; Southern 1939).

Other opportunities for raising cash to meet day-to-day needs or to repay debts were few. Animals like opossums (*Didelphis virginiana*) and skunks (*Mephitis mephitis*) could be trapped and the pelts sold for between five and ten cents apiece. Farm boys set snares for rabbits (*Lepus*) and might raise a nickel or two for the family in that way. Many a backwoods farmer added to his cash income by having a whisky still on his property, the sale of alcohol being prohibited in Oklahoma at that time. One Sequoyah County resident recalls that as a boy in the 1930s he was not even aware that whisky production was illegal, the still being an essential part of every farm operation he had seen. A Sallisaw merchant told the story of how one indebted farmer whose crops had failed came into the store to say he could not pay off his debt without robbing a bank or moonshining. The merchant told the farmer not to rob any banks and gave him 50 pounds of sugar on credit (sugar with corn and water being the main ingredients in homemade whisky).

Many eastern Oklahoman farmers had for years made it a practice to travel elsewhere in the region to seek wage employment as agricultural laborers after their own crops had been harvested. Migration was and is today in many rural societies a means of adapting to a range of climatic and non-climatic stresses and opportunities (McLeman and Smit 2006a). Traditional seasonal-migration destinations for eastern Oklahomans included western parts of Oklahoma, the Texas panhandle and the Rio Grande. Once harvests had been completed in the destinations, farmers would return home to ready their own farms for the next planting season. This seasonal migration provided additional income security for farm families that were so heavily reliant on the success of a single cash crop. In the 1930s, however, those traditional destinations had already been suffering through extended droughts for several years before drought came to eastern Oklahoma. Struggling Oklahoman farmers who nonetheless made the journey in hope of finding some employment were not simply disappointed, but by 1940 hundreds were starving in migrant labor camps along the Rio Grande as the number of available workers greatly exceeded that which was needed (Bond et al. 1940).

With the loss of seasonal migration destinations, the alternative chosen by many drought-stricken farmers was to migrate away from eastern Oklahoma for more indefinite periods, across longer distances. During the 1930s, it is estimated that more than 300,000 people left the state of Oklahoma, the largest number for neighboring states, but a full third migrated to California (Gregory 1989). So many interstate migrants flooded into rural California that the FSA was compelled to establish migrant worker camps to provide transitional accommodation. FSA statistics show that Oklahoman migrants, who made up the largest group in the camps, came from all over the state, but especially from eastern corn-and-cotton counties (Holzschuh 1939). During this period, at least two individuals in Sequoyah County earned money by transporting people to and from California as a *de facto* interstate taxi service.

Those who migrated to California from rural eastern Oklahoma were drawn primarily from the tenant farming population. Settling in California, finding employment and making the long journey were not without their costs, and so not all Oklahomans had the wherewithal to undertake migration to California. Although poor by Californian standards,

migrants tended not to be destitute; rather, they migrated as intact families, often drawing on family and social connections in California for assistance. Their agricultural skills were much in demand in California, where the seasonal influx of migrant workers from Mexico had been curtailed by stricter immigration regulations. Although some migrants would return to Oklahoma after a year or two, a great many did not, settling permanently in the tens of thousands in California's San Joaquin and Imperial valleys, giving places like Bakersfield a distinctly Oklahoman culture (Gregory 1989; McLeman 2006).

4 Failures in adaptation

Most eastern Oklahomans successfully adapted to the harsh conditions of the mid-1930s, if success is described in the simplest terms of having maintained a place of residence throughout the drought or resettling in permanent accommodation outside the drought-stricken region. This is, admittedly, a coarse test of success, but not all people were successful in meeting even this minimal threshold of adaptation. No comprehensive statistical data exist for the people left homeless or families left broken by the droughts, and given the amount of time that has since passed, it is no longer possible to conduct a direct, reliable empirical measure of those whose lives or livelihoods were most damaged. However, it is clear from secondary sources and the observations of eyewitnesses who are still alive today that the numbers were not inconsequential. We hazard a conservative estimate that those who were not successful in adapting numbered in the hundreds of people for Sequoyah County, and thousands for the eastern Oklahoma cotton & corn region as a whole.

Interviewees reported that, as drought began to strike this region, camps of landless, homeless people could be found along railway lines, riverbanks, roadside ditches and on the outskirts of towns and cities throughout eastern Oklahoma. Many more lived in crude shacks or tents in the hilly back country, squatting on unproductive land. A large shack camp sprang up on the banks of the Arkansas River in south-easternmost Sequoyah County on the outskirts of Fort Smith.

Less visible, but still present during the droughts, were breakdowns in rural families. The obituaries of young, healthy farmers where death was reported vaguely as having occurred by natural causes concealed unspoken but understood suicides. Sequoyah County established a ''poor farm'' to shelter elderly or infirm residents whose families had abandoned them. Gaunt, hungry figures were commonplace in the countryside, and a series of chilling photographs taken in 1939 by FSA photographer Russell Lee captures destitute, malnourished and disease-ridden women and children living in shacks and camps along Poteau Creek, in the Arkansas River bottomlands (Fig. 3). As with suicides and abandonment of elders, starvation is not something residents of Sequoyah then or now speak openly or willingly about, it being a source of shame for the community. Nonetheless, such things did occur.

5 Discussion

The terrible decade that was the 1930s occurred less than one human lifetime ago. Those who lived through it are a valuable source of information about the capacity of human populations to adapt to unusually harsh conditions of coinciding economic and climatic stresses. This study just scratches the surface of the body of collective wisdom about the processes of adaptation, the interaction of external stimuli and local conditions, and the factors that constrain and facilitate adaptation options.

Fig. 3 Destitute mother and child, Russell Lee, FSA photograph 1939. Library of Congress, Prints & Photographs Division, FSA-OWI Collection, LC-USF34-033601-D DLC (b&w film neg.). The caption accompanying this figure reads: ''Tubercular wife and daughter of agricultural day laborer. She had lost six of her eight children and the remaining two were pitifully thin. The mother said that she had tuberculosis because she had always gone back to the fields to work within two or three days after her children were born. Shack home is on Poteau Creek near Spiro, Oklahoma''

The population of eastern Oklahoma is still confronted by a mix of ongoing climatic and economic risks to this day. This region has experienced many severe droughts since the 1930s, including individual years in the 1950s, 1980s, 1990s and current decade that have sometimes approached or surpassed in meteorological terms the conditions described in this case (Borchert 1971; Arndt 2002; Maxwell 2006). None of these subsequent droughts has resulted in the same degree of hardship as occurred during the 1930s.

One reason is that socio-economic conditions have changed in eastern Oklahoma since the 1930s. The landscape of rural Sequoyah County is today dominated by pasturelands for beef cattle and horses, the latter no longer kept as draft animals but for recreational purposes. Rising costs of controlling boll weevils (*Anthonomus grandis*) and competition from higher-yield producers in other regions led to the abandonment of cotton production in Sequoyah by the 1950s. Row crop farms are today found only on the most productive bottomlands and production is entirely mechanized. Soybeans (*Glycine max*) are the preferred row crop.

Agriculture is no longer the linchpin of the Sequoyah County economy, and tenant farmers no longer make up a significant share of the rural population. By 2002, the number of farms in Sequoyah County had fallen to 1,259 from 2,769 in 1930 (Historical Census Browser 2004), two-thirds of which had sales of less than $10,000 and can be assumed do not provide a full income for the operator (National Agricultural Statistics Service 2002). In many upland areas, land that was marginally productive for agriculture has returned to forest cover. Since the 1930s, the total population of Sequoyah has doubled from 19,505 to 38,972 (Historical Census Browser 2004; US Census Bureau 2005). The county seat of Sallisaw (population 7,989 (US Census Bureau 2005)) hosts factories and provides a range of services, few of which are dedicated to serving the agricultural sector as was once the case. While much of the population still resides in rural areas, commuting to jobs in Sallisaw or in neighboring counties and Fort Smith, Arkansas is a much more common livelihood strategy for rural Sequoyah County residents than farming. The vulnerability of the rural population and its adaptive capacity have consequently changed since the 1930s.

While the economy of the US has never again plunged to the state of chaos that reigned during the 1930s, the rural population of eastern Oklahoma today faces ongoing economic pressures. Some, such as downward pressure on commodity prices that affects the remaining farm operators, are pressures similar to those of the 1930s. Other pressures are newer, such as rising energy costs that squeeze the profit margins of those who remain in agriculture and raise for all residents the costs of travel and of home heating and cooling. Sequoyah County does not have an especially wealthy population. The estimated 2003 median household income was $29,243, almost 20% below the state average of $35,634 (USDA Economic Research Service 2006), and so economic stresses like rising energy costs have a pronounced effect on economic well-being generally throughout the county.

Drought still remains a risk for Sequoyah County, and it is expected that climate change may exacerbate the existing range of this and other climate-related risks in the southern Great Plains and bordering areas (National Assessment Synthesis Team 2000). The impacts of drought are experienced differently today than they were in the 1930s. During the most recent phase of data collection for this research project, Sequoyah County and much of eastern Oklahoma were mired in drought. For the period July 2005 to July 2006, this region received less than 28 inches of precipitation, similar to the amount that fell during same period from 1935 to 1936 (Oklahoma Climatological Survey 2006). This drought created some hardship for Sequoyah County's farmers. Lack of grazing obliged beef cattle operators to purchase supplementary feed for their herds, and as streams and ponds ran dry, some had to choose between selling off animals or costly payments to truck water to their farms. The drought also posed significant risks for urban dwellers. Water shortages became acute and, had heavy showers not fallen in late April and early May 2006 (which caused flash flooding in some areas to the north of Sequoyah County), the municipal water supply for the city of Sallisaw was in danger of running dry.

While the risks drought presents today are different in eastern Oklahoma than they once were, there are a number of lessons that may nonetheless be taken from the past adaptive experience of residents of this region, lessons that may be broadly applicable to a variety of regions (Table 3). For example, in many developing regions today, socio-economic conditions and structures prevail that are similar to those in eastern Oklahoma during the 1930s: small farm sizes, uncertain land tenure, declining commodity prices, competition with producers in other regions, farmers with insufficient capital to adopt alternative technologies and so on. Many such regions also now face uncertain climatic futures which compound existing stresses (Leichenko and O'Brien 2002).

A first lesson from this case is that adaptation to climate-related stresses rarely, if ever, occur in isolation from other, non-climatic stresses—a finding increasingly recognized in the field of climate change adaptation (Kelly and Adger 2000; Schneider et al. 2000; Leichenko and O'Brien 2002; McLeman and Smit 2006a; Wall and Marzall 2006). Cotton farmers in eastern Oklahoma were remarkably resilient and creative when it came to finding new ways of making a living. The number of farms that operated for many decades and the dense population they supported on a landscape that is not especially favorable for agriculture is itself a testament to this. However, when climatic and non-climatic stresses occurred simultaneously, a negative synergy arose that overwhelmed the adaptive capacity of many farmers. This is because many of the strategies that households used to adapt to non-climatic stresses were the same as those used to adapt to climatic stresses.

Eastern Oklahoman farmers had been struggling with the effects of economic depression, falling commodity prices and collapsed farm incomes for several years prior to the onset of drought in the mid-1930s. The land was already being worked intensively, and farm households were already operating on the slimmest of financial margins when the

Table 3 Summary of lessons drawn from case study

Observation from 1930s eastern Oklahoma	Lesson to be taken
Strategies farmers traditionally used for adapting to climate stresses were essentially the same as those employed to adapt to socio-economic stresses. When droughts struck, these strategies had already been exhausted by years of economic stress.	Farmers experience and adapt to climate stresses in tandem with non-climatic stresses; climate adaptation research should therefore consider non-climatic stresses as well.
Farmers did not change their farm management practices and strategies in the face of severe droughts. New technologies and innovations were being practiced in other regions, but a variety of factors including under-capitalization, farm size, and prevailing land tenure structures prevented their adoption.	The theoretically possible range of farm-level adaptations are not necessarily practical or available to every farm in every region
Government agricultural programs that were not specifically targeted at drought relief nonetheless helped farmers adapt because these programs addressed the underlying problem of stabilizing farm income.	Policies and programs that foster financial stability at the farm level may enhance adaptive capacity in an anticipatory sense and reduce need for ad hoc relief when a climatic stress occurs
When cash crops failed, farmers lacked the income to invest in technologies and equipment, and in many cases sold off assets.	For many farmers, the middle of a climate crisis is not the time for making costly investments in adaptive technologies; these investments must be made when conditions are favorable.
Local levels of government, whose revenues were highly dependent on performance of the local economy, lacked the financial means to provide significant assistance to farmers.	When stressful climatic events occur, a high degree of coordination is required between all levels of government, and must be accompanied by appropriate fiscal policies and financial mechanisms for efficient transfer of funds.
Some government programs were accessible only by a small proportion of farmers given the structure of the program and the nature of landholding.	Even well-intentioned adaptation policies and programs may be unsuccessful or have adverse consequences where they do not fit well with the prevailing structure of the local agricultural system.
Farm-level adaptive capacity had eroded in the decade preceding the droughts due to underinvestment in health, education and other social services.	A healthy, well-educated and well-skilled rural population has a higher capacity to adapt to climatic and non-climatic risks. Investment in these social services has positive benefits for climate change adaptation.
Farmers had in previous decades demonstrated an impressive ability to operate productive farms on lands that were not especially well-suited for agriculture, and cope with a range of climatic and non-climatic stresses.	The nature of farming inherently develops high levels of adaptive capacity in rural populations. A threshold does exist where this capacity can be overwhelmed, especially by simultaneous occurrence of multiple stresses. Governments and higher-level actors have the ability to influence where/when this threshold occurs.

droughts struck. The geographic extent of the droughts removed a key adaptive option previously used by Oklahomans, the ability to work for seasonal wages on other farms in the region. Simultaneously, miserable economic conditions meant there was little off-farm work to be found in non-farming sectors, and large numbers of unemployed laborers competing for what opportunities did arise. Consequently, farm-level adaptive capacity was exceeded, traditional adaptive responses were unavailable and large-scale out-migration and social problems emerged.

A second lesson is that the processes of adaptation are rarely as simple as often assumed in climate change impact studies, and that many of the assumed adaptations may be impractical or uneconomic. Numerous technological adaptations, crop choices and alternative farming techniques were conceivably available to farmers in Sequoyah County during the 1930s droughts, but most farmers did not change their operations. In some cases, the alternatives were unfeasible or impractical due to the geographic character of farms, the nature of land tenure and local structure of the agricultural system; in other cases, the alternatives were simply not affordable by poor farmers. Studies of agricultural adaptation to climate change should recognize the conditions that facilitate and constrain adaptive strategies in order to accurately characterize decision-making processes and to generate more reliable and accurate projections and recommendations.

Another lesson comes from recognizing that government policies and programs that proved most beneficial to drought-stricken farmers were not actually designed for the purpose of drought relief. These programs and policies were aimed at stabilizing commodity prices, providing income stability for farmers and providing employment opportunities for the unemployed. They helped because they addressed key, underlying and fundamental elements of farm-level adaptive capacity in a broader sense. Because farmers employed a similar range of strategies to climatic and non-climatic stresses, programs that helped them respond to one type of stress were likely to help with another. The message, therefore, is that policies and programs that foster financial stability at the farm level may enhance adaptive capacity in an anticipatory sense, potentially reducing the need for ad hoc relief once a climatic stress actually occurs. Related to this point is that, once a climate-driven crisis arises, farmers may not have the financial wherewithal to undertake costly technological responses or modifications to existing operations. Such adaptive responses must be developed when conditions are favorable.

This case also showed that local levels of government, whose revenues were tied directly to the economic well-being of the population exposed to drought, were ill-resourced to provide assistance when drought struck. Had the federal government not stepped in with funding and programs, a much greater catastrophe would have ensued. Hence, if government assistance is to be practiced only when a stressful climatic event occurs (i.e. in a purely responsive fashion), a high degree of coordination involving all levels of government, accompanied by appropriate fiscal policies and financial mechanisms for transfer of funds, is essential for responsive adaptation measures to be efficient. It is evident from the chaos of post-Katrina New Orleans that such lessons remain to be learned.

Government programs related to agriculture, climate, macroeconomics, rural development, rural population change and other areas touched on in this study are clearly an important part of adaptation regimes, and they are clearly intertwined with other forms of response. Their accessibility and effectiveness may be heavily influenced by prevailing socio-economic structures. Farm support programs as structured under the Agricultural Adjustment Act included incentives to reduce acreages of crops like cotton and corn in an attempt to stabilize falling commodity prices. The land tenure system that existed in eastern Oklahoma in the 1930s meant that such incentives were really only attractive to landowning farmers, who represented a minority of farm operators in that particular region. For tenant operators, attempting to intensify and increase production was a more logical farm management strategy. Since the 1930s, a wide range of government farm support strategies has emerged, with programs such as subsidized crop insurance, and these are often cited as mechanisms that could assist agricultural adaptation to future climate change. Their potential success in doing so not be taken for granted; indeed, it is possible that such programs, depending on their structure, might actually increase farmers'

vulnerability to climate change by providing incentives that encourage farm operators to expose their operations to greater risks (McLeman and Smit 2006b).

Missed opportunities were also identified in this study. The laissez-faire agricultural and economic policies of the Hoover administration, and its turning of a blind eye to citizens in distress, directly contributed to the hardship and suffering that occurred as a result of the harsh climatic conditions of the mid-1930s. The Hoover years saw a general erosion of farm-level adaptive capacity, as individual farm households were left to cope on their own with economic and commodity price-related stresses. Had the New Deal policies been in place years earlier, there is little doubt that the climate-related crisis on eastern Oklahoma farms could have been avoided or reduced. Today, international trade organizations and governments in many developed nations are pushing for an undoing of many contemporary agricultural and social welfare policies that have their origins in the New Deal of the 1930s. It is worth reminding them of the reasons why such policies and programs were needed in the first place.

Farm-level adaptive capacity in 1930s Oklahoma was also undermined by limited availability and poor quality of economic and social services, such as publicly funded schools, utilities, health care facilities, employment insurance programs and so forth. To compensate, the rural population relied heavily on social networks and social capital. Despite the decades that have passed and the expansion of such services in developed countries, rural areas in most countries still typically lag behind urban and peri-urban regions in terms of availability, funding and quality. Public services that keep rural populations healthy, well-educated and well-skilled must receive support if those populations are to maintain a high level of capacity to adapt to climatic and non-climatic risks. When rural social networks come under stress, as they did in the 1930s, social problems like suicide and family breakdowns emerge. Not surprisingly, such problems remain pressing issues in many rural areas today (Conger and Elder Jr. 1994; Singh and Siahpush 2002).

The ultimate lesson to be taken from this study is that rural populations may have an impressive capacity to adapt to a range of climatic and non-climatic risks. However, this capacity does have limits that can be exceeded, especially when climate-related stresses are superimposed on other forces that give rise to vulnerability. Whether that threshold is exceeded is strongly influenced by the role that higher-level actors such as governments choose to play in providing adaptation assistance and capacity building. This study suggests that ongoing programs and policies that enhance the general quality of socio-economic well-being in rural areas are an efficient and effective way of increasing the ability of rural residents to adapt to climatic and non-climatic stresses generally.

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